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PROCEEDINGS

OF THE

ASSOCIATION OF MUNICIPAL AND SANITARY ENGINEERS AND SURVEYORS.

VOLUME XII.–1885-86.

EDITED BY

THOMAS COLE,

ASSOC. M. INST. C.E.

(*Secretary of the Association*).

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CONTENTS.

PAGE
List of Officers v
List of Members vii
List of Towns and Districts Represented xiv
Parliamentary Committee xviii
Rules xix
Annual Report and Financial Statement for Year ending April 30th, 1886 1
Appointment of Auditors 6
" " Scrutineers 6
" " Acting District Secretaries 6

District Meetings—

Meeting at Blackburn:

Some particulars of the Municipal and Sanitary Works of Blackburn. J. B. McCallum 9
Discussion 26
Visits to Works 32

Meeting at Bournemouth:

The Rise and Progress of Bournemouth and the Public Works in connection therewith. G. R. Andrews 33
Discussion 42
Visits to Works 45

Meeting at Stratford-upon-Avon:

Stratford-upon-Avon Water Supply. J. Edward Willcox, Assoc. M. Inst. C.E. 47
Stratford-upon-Avon Sewerage and Sewage Disposal. Alfred T. Davis, Assoc. M. Inst. C E. 55
Discussion 63
Visits to Works 76

Meeting at Gateshead:

Description of the Cast-iron Cylinder Foundation for a Quay Wall in the river Tyne at Gateshead. Jas. Bower, M.I.C.E. 77
The Efficient Disconnection of Slop-Stone Pipes. Cosmo C. Hooley, Assoc. M. Inst. C.E. 82
Visits to Works 86

27364

DISTRICT MEETINGS (*continued*)—

MEETING AT BRADFORD:

	PAGE
Municipal Work in Bradford. J. H. Cox	87
Discussion	113
Visits to Works	118

MEETING AT GREAT YARMOUTH:

Great Yarmouth, and some of the recent works of its Sanitary Authority. J. W. Cockrill	119
The Sewerage, Surface Drainage, Sewage Disposal, and House Drainage of the Market Harborough, Great and Little Bowden Local Board District. E. G. Mawbey, Assoc. M.I.C.E.	126
Discussion	144
Visit to Works	154

ANNUAL MEETING AT HANLEY—

President's Address	155
Notes on recent Sewage Operations in Nottingham and its Neighbourhood. M. Ogle Tarbotton, M. Inst. C.E., F.G.S., &c. ..	162
Discussion	188
The present aspect of the Rural Road Question, with some Remarks on the Maintenance of Macadamised Roads, &c. E. B. Ellice-Clark, M. Inst. C.E.	197
Discussion	210
The Economic Production of Coal Gas. R. P. Spice, C.E... ..	217
Discussion	227
Road-Watering. W. Santo Crimp, Assoc. M. Inst. C.E., F.G.S., M.S.I., &c.	233
Discussion	246
Correspondence	250
The Refuse Destroyer at Nelson. W. Dent	252
Discussion	256
The Public Supply of Electricity in Towns as an Illuminant. J. N. Shoolbred, B.A., M.I.C.E.	262
Discussion	267
Visits to Works	272

APPENDIX—

SYLLABUS OF EXAMINATION	273
BOARD OF EXAMINERS	279
FORM OF APPLICATION	280
FORM OF CERTIFICATE	281
THE SANITATION OF LONDON AND THE SUBURBS. E. CHADWICK, C.B.	282
MEMOIRS OF DECEASED MEMBERS	291

ASSOCIATION OF MUNICIPAL AND SANITARY ENGINEERS AND SURVEYORS.

LIST OF OFFICERS, 1886–7.

COUNCIL.

President.

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1873–4–5. LEWIS ANGELL, M. Inst. C.E., London.
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1876–7. JAMES LEMON, M. Inst. C.E., Southampton.
1877–8. F. ASHMEAD, M. Inst. C.E., Borough Engineer, Bristol.
1878–9. G. F. DEACON, M. Inst. C.E., Water Engineer, Liverpool.
1879–80. E. PRITCHARD, M. Inst. C.E., Birmingham and London.
1880–1. *A. MORANT, M. Inst. C.E., Leeds.
1881–2. W. S. TILL, M. Inst. C.E., Borough Engineer, Birmingham.
1882–3. C. JONES, Assoc. Inst. C.E., Ealing, W.
1883–4. W. H. WHITE, M. Inst. C.E., Oxford.
1884–5. W. G. LAWS, M. Inst. C.E., Newcastle.
1885–6. R. VAWSER, M. Inst. C.E., Manchester.

* Deceased.

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Ordinary Members of Council.

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J. CARTWRIGHT, M. Inst. C.E., Borough Surveyor, Bury.
T. COULTHURST, Borough Surveyor, Derby.
J. H. COX, Assoc. M. Inst. C.E., Borough Surveyor, Bradford.
E. B. ELLICE-CLARK, M. Inst. C.E., Engineer to the Commissioners, Hove.
A. M. FOWLER, M. Inst. C.E., Borough Surveyor, Stockport.
T. HEWSON, M. Inst. C.E., Borough Engineer, Leeds.
T. DE C. MEADE, Assoc. M. Inst. C.E., Surveyor to the Local Board, Hornsey.
A. W. PARRY, Assoc. M. Inst. C.E., Borough Surveyor, Reading.
R. READ, Assoc. M. Inst. C.E., City Surveyor, Gloucester.
T. WALKER, Assoc. M. Inst. C.E., Borough Surveyor, Croydon.

District Honorary Secretaries.

Home Counties District.—O. C. ROBSON, Assoc. M. Inst. C.E., Willesden.
Midland Counties District.—E. PRITCHARD, M. Inst. C.E., Birmingham.
Yorkshire District.—J. W. HORSFIELD, C.E., Batley.
Lancashire and Cheshire District.—S. S. PLATT, Assoc. M. Inst. C.E., Rochdale.
Western District.—JOS. HALL, Assoc. M. Inst. C.E., Torquay.
Northern District.—P. W. THOMSON, C.E., Willington Quay, Northumberland.
Eastern Counties District.—E. BUCKHAM, Assoc. M. Inst. C.E., Ipswich.
Wales.—J. W. M. SMITH, Wrexham.

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C. JONES, Assoc. Inst. C.E., Ealing, W.

Treasurer.

LEWIS ANGELL, M. Inst. C.E., London.

Secretary.

THOMAS COLE, Assoc. M. Inst. C.E., 6, Westminster Chambers, London, S.W.

HONORARY MEMBERS.

BAZALGETTE, Sir JOSEPH, C.B., M. Inst. C.E.	Metropolitan Board of Works.
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HAYWOOD, W., M. Inst. C.E.	Guildhall, City of London.
MANSERGH, JAS., M. Inst. C.E.	Westminster.
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SMITH, S. J., C.E.	Local Government Board, Whitehall.
TULLOCH, Major H., R.E., Assoc. Inst. C.E.	Local Government Board, Whitehall.

MEMBERS.

Allen, T. T...	Broad Street, Stratford-on-Avon.
Allies, E. H., Assoc. M. Inst. C.E.	Surveyor to the Local Board, West Derby, Liverpool.
Allison, J., Assoc. M. Inst. C.E.	City Surveyor, Manchester.
Allsopp, John, Assoc. M. Inst. C.E.	Late Surveyor to the Local Board, Worksop, Nottingham.
Andrews, G. R.	Town Hall Chambers, Bournemouth.
ANGELL, L., M. Inst. C.E. (*Past President and Treasurer.*)	West Ham Local Board, Town Hall, Stratford, London, E.
Armistead, Richard, Assoc. M. Inst. C.E.	Surveyor to the Improvement Commissioners, Bingley, Yorkshire.
ASHMEAD, F., M. Inst. C.E. (*Past President.*)	Borough Engineer, Bristol.
Baker, F., Assoc. M. Inst. C.E.	Late Town Surveyor, Loughborough. (Waterworks, Leicester).
Banks, W.	City Surveyor, Rochester.
Barley, W. C., Assoc. M. Inst. C.E.	Borough Surveyor, Ramsgate.
Barlow, J.	Surveyor to the Local Board, Alton, Hants.
Barret, W. L., Assoc. M. Inst. C.E.	Surveyor to the Local Board, Bognor.
Batten, W., Assoc. M. Inst. C.E.	150, Lozells Road, Handsworth, near Birmingham.
Beaumont, J.	Late Borough Surveyor, Beverley.
Bennett, T.	Surveyor to the Local Board, Cheshunt.
Biddle, G.	L. and N. W. Ry. Estate Department, Lime Street Station, Liverpool.
Blackshaw, W.	Borough Surveyor, Stafford.
Blair, W. N...	Borough Surveyor, Bootle-cum-Linacre.
Bland, D.	Surveyor to the Local Board, Chesterton, Cambridge.
Boulnois, H. P., M. Inst. C.E. (*Member of Council.*)	Borough Engineer, Portsmouth.

Bourne, J.	Town Surveyor, Ashbourne, Derbyshire.
Bowen, W.	Borough Surveyor, Stoke-on-Trent.
Bower, Jas., M. Inst. C.E.	Borough Engineer, Gateshead-on-Tyne.
Bressey, J. T.	Surveyor to the Local Board, Wanstead, Essex.
Brierley, R.	Town Surveyor, Newton-in-Makerfield, Lancashire.
Bromley, W. B., Assoc. M. Inst. C.E.	Surveyor to the Local Board, Heston and Isleworth.
Brooke, W., Assoc. M. Inst. C.E.	Town Surveyor, Richmond.
Broughton, Thomas	Bolton Abbey, Skipton, Yorkshire.
Brown, Arthur, Assoc. M. Inst. C.E. (*Member of Council.*)	Borough Engineer, Nottingham.
Brown, Jos. W.	Town Surveyor, West Hartlepool.
Brumell, G. W.	Surveyor to the Local Board, Finchley.
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Buchan, J., Assoc. M. Inst. C.E.	Borough Surveyor, Great Grimsby.
Buckham, E., Assoc. M. Inst. C.E.	Borough Surveyor, Ipswich; *Hon. Secretary*, Eastern Counties District.
Burton, J. H.	Surveyor to the Local Board, Audenshaw, Lancashire.
Button, F. S.	Borough Surveyor, Accrington.
Carlton, G. B., Assoc. M. Inst. C.E.	Engineer to the Local Board, Beckenham.
Cartwright, J., M. Inst. C.E. (*Member of Council.*)	Borough Surveyor, Bury, Lancashire.
Chart, R. M.	Surveyor to the Rural Sanitary Authority, Croydon.
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Clavey, E.	Borough Surveyor, Burton-upon-Trent.
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Comber, F. C.	Town Surveyor, Bray, Ireland.
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Cousins, E., M. Inst. C.E.	Late Borough Surveyor, Swansea: 9 Bridge Street, Westminster.
Cox, J. H., Assoc. M. Inst. C.E (*Member of Council.*)	Borough Surveyor, Town Hall, Bradford.
Crabtree, W., M. Inst. C.E.	Borough Surveyor, Southport.
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Crimp, W. Santo, Assoc. M. Inst. C.E.	Surveyor to the Local Board, Wimbledon.
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Davies, R.	Borough Surveyor, Brecknock.
Davies, W. A.	Surveyor to the Local Board, Aston Manor.
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Dawson, T.	Surveyor to the Local Board, Benwell, near Newcastle-on-Tyne.
Dawson, W., Assoc. M. Inst. C.E.	Surveyor to the Local Board, Leyton, E.
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Dent, William	Surveyor to the Local Board, Nelson-in-Marsden, Lancashire.
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Dixon, Isaac	Surveyor to the Local Board, Wavertree.
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Gledhill, T.	Town Surveyor, Heckmondwike, Yorkshire.
Godfrey, R.	Surveyor to the Rural Sanitary Authority, King's Norton, near Birmingham.
Goldsworth, W.	Surveyor to the Local Board, Prescot, Lancashire.
Gomoszynski, C. T.	Borough Engineer, Tynemouth.
Goodall, S. A.	Surveyor to the Local Board, Fenton.
Goodyear, H.	Borough Surveyor, Colchester.
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Gray, W. H.	Borough Surveyor, Tewkesbury, Gloucestershire.
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Grieves, R.	Surveyor to the Local Board, Hexham.
Grimley, S. S.	Surveyor to the Local Board, Hendon.
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Haigh, Jon.	Town Surveyor, Abergavenny.
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Hall, Joseph, Assoc. M. Inst. C.E.	Surveyor to the Local Board, Torquay; *Hon. Secretary*, Western Counties District.
Hall, M.	Borough Surveyor, South Shields, Durham.
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Haller, J. C., Assoc. M. Inst. C.E.	Surveyor to the Local Board, Swinton, near Rotherham.

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Heys, Joseph	Surveyor to the Local Board, Hurst Brook, Ashton-under-Lyne.
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Hiscocks, A. M.	Surveyor to the Parish of St. George the Martyr, Southwark.
Hodge, R.	Late Borough Surveyor, Plymouth.
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Holt, A., Assoc. M. Inst. C.E.	Borough Surveyor, Lewes, Sussex.
Hooley, Cosmo C., Assoc. M. Inst. C.E.	Rural Sanitary Authority, Barton-upon-Irwell, Patricroft.
Hooley, E. P.	Surveyor to the Rural Sanitary Authority, Maidstone.
Hooper, J. D.	Surveyor to the Local Board, Woodford, Essex.
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Howard, W. F., Assoc. M. Inst. C.E.	13, Cavendish Street, Chesterfield.
Howcroft, James	Surveyor to the Local Board, Kirkleatham, Yorkshire.
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Hutchinson, R.	Borough Surveyor, Huntingdon.
Inch, R. H., Assoc. M. Inst. C.E.	Town Surveyor, Lowestoft, Suffolk.
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Jerram, G. B., Assoc. M. Inst. C.E.	Surveyor to the Local Board, Walthamstow, Essex.
Jones, A. S., Lt.-Col., V.C., Assoc. M. Inst. C.E.	Engineer to Urban Sanitary Authority, Wrexham.
JONES, C., Assoc. Inst. C.E. (*Past President and General Hon. Secretary.*)	Surveyor to the Local Board, Ealing, Middlesex.
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Lockwood, P. C., M. Inst. C.E.	Borough Surveyor, Brighton, Sussex.
Lofthouse, J. P.	Town Surveyor, Stroud, Gloucestershire.
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Lovejoy, C. C.	Local Board, Watford, Herts.
Lund, J.	Borough Surveyor, Bedford.

MacBrair, R. A., Assoc. M. Inst. C.E.	Surveyor to the Local Board, Lincoln.
Mann, Jabez	Surveyor to the Local Board, Sevenoaks.
Marks, T. T., Assoc. M. Inst. C.E.	Town Surveyor, Llandudno, Carnarvonshire.
Mathews, G. S.	Surveyor to the Local Board, Dorking.
Maughan, J.	Late Borough Surveyor, Great Grimsby, Lincolnshire.
Mawbey, E. G., Assoc. M. Inst. C.E.	Borough Surveyor, King's Lynn.
Mawson, Jno.	Surveyor to the Local Board, Crompton.
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Mayor, T.	Surveyor to the Local Board, Gorton near Manchester.
McBeath, A. G.	Surveyor to the Local Board, Sale, Cheshire.
McCallum, J. B.	Borough Engineer, Blackburn.
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Meade, T. De Courcy, Assoc. M. Inst. C.E. (*Member of Council.*)	Surveyor to the Local Board, Hornsey.
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Middlemiss, T. W.	Surveyor to the Local Board, Morpeth.
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Morgan, W. B.	Borough Surveyor, Weymouth and Melcombe Regis, Dorsetshire.
Morris, Jno.	Surveyor to the Local Board, Neston.
Mountain, A. H.	Surveyor to the Local Board,Swinton (Lancashire).
Myatt, J.	Town Surveyor, Leek.

Newman, F.	Borough Engineer, Ryde, Isle of Wight.
Newton, J., M. Inst. C.E.	Carlton Buildings, Manchester; Engineer to the Local Board, Bowdon, Cheshire.

Parker, J.	City Surveyor, Hereford.
Parkinson, Jas.	Surveyor to the Local Board, Turton, near Bolton.
Parry, A. W., Assoc. M. Inst. C.E. (*Member of Council.*)	Borough Surveyor, Reading.
Pattison, J., jun.	Borough Surveyor, Newcastle-under-Lyme.
Penty, W. G.	Surveyor to the Rural Sanitary Authority, York.
Perry, Wm.	Town Surveyor, Stourbridge.
Petree, J.	Borough Surveyor, Jarrow.
Pickering, Richard	11, Lowther Street, Whitehaven.
Pilditch, J. T.	Surveyor to the Parish of Battersea.
Platt, S. S., Assoc. M. Inst. C.E. (*Member of Council.*)	Borough Surveyor, Rochdale, *Hon. Secretary*, Lancashire and Cheshire District.
Pollard, J., Assoc. M. Inst. C.E.	Late Surveyor to the Local Board, Hendon, 7, Gt. Queen Street, Westminster.

Porter, R.	Borough Surveyor, Wakefield.
Price, John, Assoc. M. Inst. C.E.	Surveyor to the Local Board, Toxteth Park, Liverpool.
PRITCHARD, EDWARD, M. Inst. C.E. (*Past President.*)	37, Waterloo Street, Birmingham, and 2 Storey's Gate, S.W.; *Hon. Secretary*, Midland Counties District.
Proctor, J., M. Inst. C.E.	Borough Surveyor (Consulting), Bolton, Lancashire.
Purnell, E. J.	City Surveyor, Coventry, Warwickshire.

Ramsden, A.	Surveyor to the Local Board, Chiswick.
Read, Richard, Assoc. M. Inst. C.E. (*Member of Council.*)	City Surveyor, Gloucester.
Richardson, Jas.	Urban Sanitary Authority, Stamford.
Ricketts, F. J.	124, Mansfield Road, N.W.
Robinson, W. J.	City Surveyor, Londonderry.
Robson, O. C., Assoc. M. Inst. C.E. (*Member of Council.*)	Surveyor to the Local Board, Willesden, Middlesex; *Hon. Secretary*, Home Counties District.
Rothwell, E.	Late Surveyor to the Local Board, Norden near Rochdale.
Rounthwaite, R. S.	Borough Engineer, Sunderland.
Rowe, Wm.	Tiverton, Devon.
Rowley, S. F.	Surveyor to the Local Board, Tipton.
Royle, H., Assoc. M. Inst. C.E.	Surveyor to the Local Board, Stretford, Lancashire.
Rumble, F. J.	Surveyor to the Local Board, New Barnet.

Sadler, G. W.	Surveyor to the Sanitary Authority, Cheltenham.
Savage, Wm. Hy.	Surveyor to the Local Board, East Ham.
Scott, R. S.	Surveyor to the Local Board, Ventnor, Isle of Wight.
Sharman, E.	Surveyor to the Local Board, Wellingborough, Northamptonshire.
Sharp, J. Fox, M. Inst. C.E.	Late Borough Surveyor, Hull.
Sheppard, Geo.	Borough Surveyor, Newark.
Shuttleworth, F. H.	Surveyor to the Local Board, Littleborough, Lancashire.
Simpson, John, jun.	Late Surveyor to the Local Board, Matlock.
Smith, G. F.	Surveyor to the Local Board, Milverton, Warwickshire.
Smith, J. W. M.	Borough Surveyor, Wrexham, Denbighshire, *Hon. Secretary*, Wales District.
Spencer, J. P., Assoc. M. Inst. C.E.	50, Side, Newcastle-on-Tyne.
Spinks, W., Assoc. M. Inst. C.E.	Surveyor to the Local Board, Dukinfield.
Stafford, J. E., Assoc. M. Inst. C.E.	Borough Engineer, Burnley.
Stainthorpe, T. W.	Surveyor to the Eston District Local Board.
Stansfield-Brun, J., Assoc. M. Inst. C.E.	Surveyor to the Local Board, Oldbury.
Stevens, George	Borough Surveyor, Godmanchester.
Stewart, Wm.	Surveyor to the Local Board, Rugby.
Strachan, G. R.	Surveyor, Chelsea.
Stringfellow, H. W.	City Surveyor, Chichester.
Stubbs, Wm., Assoc. M. Inst. C.E.	Borough Surveyor, Over Darwen.
Swarbrick, Joseph, Assoc. M. Inst. C.E.	Surveyor to the Local Board, Withington, near Manchester.
Sykes, Ed.	Surveyor to the Local Board, Reddish.

Taylor, H.	Surveyor to the Local Board, Clevedon, Somerset.
Thomas, John	Surveyor to the Rural Sanitary Authority, Swansea.

Thomas, W., Assoc. M. Inst. C.E.	Borough Surveyor, Dorchester.
Thompson, R.	Surveyor to the Local Board, Waterloo, near Liverpool.
Thoms, G. E., M. Inst. C.E.	Borough Engineer, Wolverhampton.
Thomson, P. W., Assoc. M. Inst. C. E. (*Member of Council.*)	Surveyor to the Local Boards of Willington Quay and Wallsend, Northumberland; *Hon. Secretary*, Northern District.
Thorburn, T. C.	Borough Surveyor, Birkenhead.
Thorrold, S. E.	Surveyor to the Local Board, South Stockton.
TILL, W. S., M. Inst. C.E. (*Past President.*)	Borough Engineer, Birmingham.
Tomes, C.	Borough Surveyor, Eastbourne.
Trapp, S. C.	88, Mosley Street, Manchester.
Tudor, E. C. B.	Surveyor to the Local Board, Goole, Yorkshire.
VAWSER, R., M. Inst. C.E. (*Past President.*)	17, Cooper Street, Manchester.
Walker, T., Assoc. M. Inst. C.E. (*Member of Council.*)	Borough Surveyor, Croydon, Surrey.
Wallis, T. W.	Borough Surveyor, Louth.
Wardle, J. W.	Borough Surveyor, Longton.
Webster, J. L.	Borough Surveyor, Malton.
Welburn, W.	Surveyor to the Middleton and Tonge Improvement Commissioners, Middleton near Manchester.
Wheeler, W. H., M. Inst. C.E.	Borough Surveyor, Boston, Lincolnshire.
WHITE, W. H., M. Inst. C.E. (*Past President.*)	Engineer to the Local Board, Oxford.
Whitlow, Henry	Surveyor to the Local Board, Ulverston.
Whittington, W.	Borough Surveyor, Neath.
Wilds, W. H.	Borough Engineer, Hertford.
Wilkinson, J. P.	Surveyor to the Local Board, Newton Heath, near Manchester.
Willcox, J. E., Assoc. M. Inst. C.E	118 Colmore Row, Birmingham.
Wilson, J. B.	Surveyor to the Local Board, Arlecdon and Frizington, Cumberland.
Wilson, J.	Surveyor to the Local Board, Bacup, Lancashire.
Wilson, William	Surveyor to the District Local Board, Dalton-in-Furness.
Winship, G., Assoc. M. Inst. C.E.	Borough Surveyor, Abingdon, Berks.
Witts, J. W.	Town Surveyor, Skelton in Cleveland.
Wolstenholme, J.	Borough Surveyor, Blackpool.
Wood, A. R.	Surveyor to the Local Board, Tunstall.
Woodbridge, C. A.	Surveyor to the Local Board, Pinner.
Worswick, R. A.	Surveyor to the Local Board, Saltburn-by-the-Sea.
Worth, J. E., Assoc. M. Inst. C.E.	Borough Engineer, Burslem.
Wright, J.	Borough Surveyor, Macclesfield, Cheshire.

GRADUATE.

Fenton, W. C.	Borough Surveyor's Office, Sheffield.

TOWNS AND DISTRICTS REPRESENTED BY MEMBERS OF THE ASSOCIATION.

Abergavenny	Jon. Haigh.
Abingdon	G. Winship.
Abram	Geo. Heaton.
Accrington	F. S. Button.
,,	E. Knowles.
Aldershot	W. L. Coulson.
Alton	J. Barlow.
Arlecdon	J. B. Wilson.
Ashton-under-Lyne	J. T. Earnshaw.
Aspull	Geo. Heaton.
Aston Manor	W. A. Davies.
Audenshaw	J. H. Burton.
Bacup	J. Wilson.
Barking	C. J. Dawson.
Barrow-in-Furness	W. H. Fox.
Barton-upon-Irwell (Rural)	C. C. Hooley.
Barton, Eccles, Winton, and Monton	T. Heywood.
Batley	J. W. Horsfield.
Battersea	J. T. Pilditch.
Beckenham	G. B. Carlton.
Bedford	J. Lund.
Benwell	T. Dawson.
Beverley	J. Beaumont.
Bingley	R. Armistead.
Birkenhead	T. C. Thorburn.
Birmingham	W. S. Till.
,,	E. Pritchard.
Blackburn	J. B. McCallum.
Blackpool	J. Wolstenholme.
Blaydon-on-Tyne	M. Hawdon.
Bognor	W. L. Barret.
Bolton	J. Proctor.
Bootle-cum-Linacre	W. N. Blair.
Boston	W. H. Wheeler.
Bournemouth	G. R. Andrews.
Bowdon	J. Newton.
Bradford	J. H. Cox.
Bray, Ireland	F. C. Comber.
Brecknock	R. Davies.
Brentford	F. W. Lacy.
Bridgewater	G. B. Laffan.
Bridlington	S. Dyer.
Brighton	P. C. Lockwood.
Bristol	F. Ashmead.
Bromley	H. S. Cregeen.
Burnley	J. E. Stafford.
Burslem	J. E. Worth.
Burton-upon-Trent	E. Clavey.
Bury	J. Cartwright.
,,	J. Farrar.
Buxton	J. Hague.

Canterbury	J. G. Hall.
Carlisle	H. U. McKie.
Chelsea	G. R. Strachan.
Cheltenham	G. W. Sadler.
Cheshunt	T. Bennett.
Chester	I. M. Jones.
Chesterfield	W. F. Howard.
Chesterton	D. Bland.
Chichester	H. W. Stringfellow.
Chiswick	A. Ramsden.
Clevedon, Somerset	H. Taylor.
Colchester	H. Goodyear.
Compton Gifford	J. C. Inglis.
Coventry	E. J. Purnell.
Crewe	G. Eaton-Shore.
Crompton	J. Mawson.
Croydon	T. Walker.
„ (Rural)	R. M. Chart.
Dalton-in-Furness	William Wilson.
Derby	Thos. Coulthurst.
Dorchester	W. Thomas.
Dorking	G. S. Mathews.
Dover	M. Curry.
Dudley	J. Gammage.
Dukinfield	W. Spinks.
Ealing	C. Jones.
Eastbourne	C. Tomes.
East Ham	W. H. Savage.
Epsom	J. R. Harding.
Eston District	T. W. Stainthorpe.
Fenton	S. A. Goodall.
Finchley	G. W. Brumell.
Fleetwood	M. S. Gaulter.
Gateshead-on-Tyne	J. Bower.
Gloucester	R. Read.
Godmanchester	Geo. Stevens.
Goole, Yorkshire	E. C. B. Tudor.
Gorton	T. Mayor.
Grantham, Lincolnshire	S. G. Gamble.
Great Crosby	W. Hall.
Great Grimsby	J. Buchan.
„ „	J. Maughan.
Great Yarmouth	J. W. Cockrill.
Halifax	E. R. S. Escott.
Hanley	J. Lobley.
Harwich	H. Ditcham.
Heckmondwike	T. Gledhill.
Hendon	S. S. Grimley.
Hereford	J. Parker.
Hertford	W. H. Wilds.
Heston and Isleworth	W. B. Bromley.
Hexham	R. Grieves.
Heywood	J. Diggle.
Hornsea	P. Gaskell.
Hornsey	T. De C. Meade.
Hove	E. B. Ellice-Clark.

Hull	J. Fox Sharp.
Huntingdon	R. Hutchinson.
Hurst Brook	J. Heys.
Hyde	J. Mitchell.
Ipswich	E. Buckham.
Islington	C. Higgins.
Jarrow	J. Petree.
Kidderminster	A. Comber.
King's Lynn	E. G. Mawbey.
King's Norton	R. Godfrey.
Kirkleatham	J. Howcroft.
Lancaster	A. Creer.
Leeds	T. Hewson.
Leek	J. Myatt.
Leicester	J. Gordon.
Lewes	A. Holt.
Leyton, E.	W. Dawson.
Lincoln	R. A. MacBrair.
Littleborough	F. H. Shuttleworth.
Liverpool	C. Dunscombe.
„	G. F. Deacon.
„	G. Biddle.
Llandudno	T. T. Marks.
Londonderry, Ireland	W. J. Robinson.
Longton	J .W. Wardle.
Loughborough	Geo. Hodson.
Louth	T. W. Wallis.
Lowestoft	R. H. Inch.
Luton, Bedfordshire	W. H. Leete.
Macclesfield	J. Wright.
Maidstone	F. J. C. May.
„ (Rural)	E. P. Hooley.
Malton	J. L. Webster.
Manchester	J. Allison.
„	S. C. Trapp.
„	R. Vawser.
Matlock	J. Simpson, jun.
Melton Mowbray	E. Jeeves.
Merthyr Tydfil	S. Harpur.
Middlesbrough	E. D. Latham.
Middleton (Lancashire)	W. Welburn.
Milverton	G. F. Smith.
Mirfield	F. H. Hare.
Morpeth	T. W. Middlemiss.
Neath	W. Whittington.
Nelson-in-Marsden	W. Dent.
Neston	J. Morris.
Newark	Geo. Sheppard.
New Barnet	F. J. Rumble.
Newcastle-on-Tyne	W. G. Laws.
„	J. P. Spencer.
Newcastle-under-Lyme	J. Pattison, jun.
Newton Heath	J. P. Wilkinson.
Newton-in-Makerfield	R. Brierley.

Norden	E. Rothwell.
North Bierley	J. Cook.
Nottingham	A. Brown.
Oldbury	J. Stansfield-Brun.
Orrell	G. Heaton.
Over Darwen	W. Stubbs.
Oxford	W. H. White.
Pemberton	Geo. Heaton.
Pinner	C. A. Woodbridge.
Plymouth	R. Hodge.
Poole	J. Elford.
Portsmouth	H. P. Boulnois.
Prescot	W. Goldsworth.
Ramsgate	W. C. Barley.
Reading	A. W. Parry.
Reddish	E. Sykes.
Rhyl	Robt. Hughes.
Richmond	W. Brooke.
Rochdale	S. S. Platt.
Rochester	W. Banks.
Rotherham	G. Jennings.
Rugby	W. Stewart.
Ryde	F. Newman.
Sale	A. G. McBeath.
Saltburn-by-the-Sea	R. A. Worswich.
Sevenoaks	J. Mann.
Sheffield	R. Davidson.
Skelton in Cleveland	J. W. Witts.
Sleaford	Jesse Clare.
Southampton	J. Lemon.
Southgate	C. G. Lawson.
Southport	W. Crabtree.
South Hornsey	Ed. Fry.
South Shields	M. Hall.
South Stockton	S. E. Thorrold.
Stafford	W. Blackshaw.
Stamford	Jas. Richardson.
Stockport	A. M. Fowler.
Stoke-on-Trent	W. Bowen.
Stourbridge	W. Perry.
Stratford-on-Avon	A. T. Davis.
” ”	T. T. Allen.
Stretford	H. Royle.
Stroud	J. P. Lofthouse.
St. George the Martyr, Southwark	A. M. Hiscocks.
St. Thomas, near Exeter	S. Churchward.
Sunderland	R. S. Rounthwaite.
Swansea (Rural)	J. Thomas.
Swinton, Yorkshire	J. C. Haller.
Swinton and Pendlebury, Lancashire	A. H. Mountain.
Tewkesbury, Gloucestershire	W. H. Gray.
Tipton	S. F. Rowley.
Tiverton, Devon	Wm. Rowe.
Todmorden	A. Greenwood.

Torquay	Joseph Hall.
Toxteth Park	J. Price.
Tunstall	A. R. Wood.
Turton	Jas. Parkinson.
Tynemouth	C. T. Gomoszynski.
Ulverston	Hy. Whitlow.
Ventnor	R. S. Scott.
”	J. G. Livesay.
Wakefield	R. Porter.
Walsall	A. Hardwicke.
Walsoken	J. Kerridge.
Walthamstow	G. B. Jerram.
Walton on the Hill	S. Middlebrook.
Wanstead	J. T. Bressey.
Warminster	T. Cruse.
Warrington	T. Longdin.
Waterloo, Liverpool	R. Thompson.
Watford	C. C. Lovejoy.
Wavertree	J. Dixon.
Wellingborough	E. Sharman.
West Bromwich, Staffordshire	J. T. Eayrs.
West Derby, Liverpool	E. H. Allies.
West Ham, London	L. Angell.
West Hartlepool	J. W. Brown.
Weymouth and Melcombe Regis	W. B. Morgan.
Whitehaven	R. Pickering.
Willesden	O. C. Robson.
Willington Quay, Northumberland	P. W. Thomson.
Wimbledon	W. Santo Crimp.
Withington	J. Swarbrick.
Wolverhampton	G. E. Thoms.
Woodford	J. D. Hooper.
Worksop	J. Allsopp.
Wrexham	J. W. M. Smith.
”	A. S. Jones.
York (Rural)	W. G. Penty.

PARLIAMENTARY COMMITTEE.

E. B. Ellice-Clark (Hove), *Chairman.*

Lewis Angell (West Ham).
Chas. Jones (Ealing).
T. De C. Meade (Hornsey).
A. Parry (Reading).
O. C. Robson (Willesden).
W. H. White (Oxford).

RULES OF THE ASSOCIATION.

I.—That the Society be named the "ASSOCIATION OF MUNICIPAL AND SANITARY ENGINEERS AND SURVEYORS."

II.—That the objects of the Association be—

a. The promotion and interchange among its Members of that species of knowledge and practice which falls within the department of an Engineer or Surveyor engaged in the discharge of the duties imposed by the Public Health, Local Government, and other Sanitary Acts.

b. The promotion of the professional interests of the Members.

c. The general promotion of the objects of Sanitary Science.

III.—That the Association consist of Civil Engineers and Surveyors holding chief permanent appointments under the various Municipal Corporations or Sanitary Authorities within the control of the Local Government Board, or under the Metropolis Local Management Acts. Each Candidate for Membership shall be proposed by at least two Members, who from personal knowledge of such Candidate shall certify that he possesses the necessary qualification. Members who cease to hold their appointments are eligible for re-election by the Council, but will be disqualified from holding any office. Civil Engineers and Surveyors holding other chief permanent appointments under any Public Authority within the United Kingdom, or in the Colonies or Foreign Countries, shall be eligible for election as Members, subject to the approval of the Council. The Council shall also have power to elect such Honorary Members as they may see fit.

IV.—That the Affairs of the Association be governed by a Council, consisting of a President, Three Vice-Presidents, Twelve Members, and an Honorary Secretary, to be elected annually. The Past Presidents and the District Secretaries for the time being shall also be Members of the Council.

V.—That the Council shall nominate one name for President, three for Vice-Presidents, one for Honorary Secretary, and fifteen for Ordinary Members of Council. In addition to these each Member of the Association shall be at liberty to nominate one Member for the Council, but in the event of the last-named Nominations exceeding fifteen, the Council shall reduce them to that number, so as to leave thirty names in all from which to elect the required number of Ordinary Members of Council. Members' Nominations must be in the hands of the Secretary on or before the 20th of April in each year. And in case the Members' Nominations should not reach fifteen, the Council shall have the power to make up the total number of Nominations to thirty. Such list of thirty Nominations shall be printed and sent to each Member of the Association not less than fourteen days previous to the Annual Meeting. Every Member shall be entitled to vote for or erase any of such Nominations or substitute other names, subject in all cases to the limits of Rule IV., and return the same within seven days from the date of issue. Such ballot papers shall be examined in London by the President, Secretaries, and two Scrutineers appointed at the previous Annual Meeting, or by any two of the aforesaid Members. Any Member canvassing for votes for the office of Member of Council shall be considered ineligible for election.

VI.—That the Association be formed into District Committees which shall include the whole of the Members. Such Committees shall meet from time to time, in convenient centres, for the discussion of matters of local and general interest connected with the Association. Each District Committee shall appoint a District Secretary, who will keep records of local proceedings, and communicate with the Council. All District Secretaries shall vacate their office at the Annual Meeting, and Members shall then be appointed to act as Local Secretaries until a District Meeting can be arranged, at which Meeting a District Secretary shall be appointed.

VII.—That a General Meeting and Conference of the Association shall be held annually in such towns, in rotation, as may afford convenient centres for assembling the Members.

VIII.—That an entrance-fee of One Guinea, and a subscription of One Guinea per annum, from Civil Engineers and Surveyors under Rule III., shall constitute Membership of the Association.

IX.—That no new Rule or alteration of any existing Rule be made unless Notice of Motion for such purpose and the proposed Resolution thereon be sent to the Secretary by the 31st March, and such Notice of Motion and Resolution shall be printed in the Agenda for the ensuing Annual Meeting.

X.—That Candidates successful in obtaining certificates of competency at any examination under the auspices of the Association, and who are not otherwise qualified as Members of the Association, shall constitute a class of graduates on payment of an annual subscription of One Guinea; and as such shall be entitled to attend the General and District Meetings and to take part in the proceedings thereof, and be entitled to a copy of the Minutes of the Proceedings, but shall not take part in the election of the Council. Graduates shall be transferred to the class of member when qualified according to Rule III. A graduate shall not be required to pay an entrance fee either on his becoming a Graduate or on his transfer as a Member.

UNIVERSITY OF
LIBRARY
ILLINOIS.

ASSOCIATION OF MUNICIPAL AND SANITARY ENGINEERS AND SURVEYORS.

THIRTEENTH ANNUAL MEETING.

Hanley, *July* 8*th*, 9*th*, *and* 10*th*, 1886.

GENERAL BUSINESS.

The Members assembled in the Town Hall, Hanley, when Mr. R. Vawser, President, took the chair, and the Minutes of the Annual Meeting, held in London in June 1885, were read, confirmed, and signed.

The Secretary then read the Annual Report and Statement of Accounts for the year ending April 30th, 1886.

ANNUAL REPORT.

The Council have much pleasure in again meeting the Members and in presenting the Annual Report of the proceedings of the past year. They have much satisfaction also in being able to state that the progress of the Association is fairly maintained.

The following District Meetings have been held since the General Meeting in London on the 25th of June, 1885, and the two following days. At Blackburn, on the 24th of August; at Bournemouth, on the 17th of October; at Stratford-on-Avon, on the 14th of November; at Gateshead-on-Tyne, on the 12th of December; at Bradford, on the 10th of April; and at Great Yarmouth, on the 5th of June. The importance of these meetings and the value of the visits to works which are connected with them, are warmly appreciated by all those Members who are enabled to attend them; whilst the recognition shown in the welcome and hospitality invariably accorded to the Association by municipal authorities is a matter of special congratulation.

During the past year twenty-five new Members have joined the Association, four Members have resigned, eleven names have been written off; and the Council regret to report the deaths of Mr. H. S. Aspinwall, formerly borough surveyor of Macclesfield, and Mr. James Hall, of Stockton-on-Tees.

The number on the roll of the Association at the close of the year was—6 Honorary Members, 244 Ordinary Members, making 250 in all.

The duly audited Balance Sheet which accompanies this Report shows a balance in hand on the 30th April of 206*l.* 4*s.* 3*d.* This, taken in connection with the statement of assets and liabilities, marks the satisfactory position and steady prosperity of the Association.

The Ballot lists having been duly issued, the Scrutineers report the following gentlemen elected for the Council:—

President.—J. Lobley.

Vice-Presidents.—C. Dunscombe, J. Gordon, and H. N. McKie.

Ordinary Members of Council.—H. P. Boulnois, A. Brown, J. Cartwright, T. Coulthurst, J. H. Cox, E. B. Ellice-Clark, A. M. Fowler, T. Hewson, T. De C. Meade, A. W. Parry, R. Read, and T. Walker.

Honorary Treasurer.—L. Angell.

Honorary Secretary.—C. Jones.

Appended to their Report is a protest, signed by the Scrutineers present at the scrutiny, setting forth "that the Form of the Ballot Paper is not in accordance with the Rules, owing to the names nominated by the Members being distinguished from those nominated by the Council."

The proposed admission of engineers and surveyors holding similar appointments in London to those which the members of the Association hold in the provinces has been carefully considered; and after giving much attention to the subject, the Council consider that the accession of Metropolitan members will advantageously enlarge the basis of the Association, and recommend the following amendment to Rule III.:—

"That the Association consist of Civil Engineers and Surveyors holding chief permanent appointments under the various Municipal Corporations or Sanitary Authorities within the control of the Local Government Board, *or under the Metropolis Local Management Acts.*"

The Council also recommend a further amendment to Rule III., as follows :—

"Civil Engineers and Surveyors holding permanent appointments under any Public Authority within the United Kingdom or in the Colonies or Foreign Countries, shall be eligible for election as Members, subject to the approval of the Council. The Council shall also have power to elect such Honorary Members as they may see fit."

Complaints having been made showing the inconvenience of six nominations for three vacancies as Vice-Presidents, the Council propose to assimilate the practice of this Association to that of the Institution of Civil Engineers in respect to these nominations, by amending Rule V. as follows :—

"The Council shall nominate one name for President, *three* for Vice-Presidents, &c."

And as the Members have not on the occasion of the recent Ballot availed themselves of their power to nominate fifteen members, the Council recommend an addition to Rule V. as follows, giving the Council power to make good any deficiency in future, so that there will always be thirty names on the Ballot list left, from whom to select the fifteen ordinary members of the Council :—

"That in case the Members' nomination should not reach fifteen, the Council shall have power to make up the total number of nominations to thirty."

The first of the examinations under the auspices of this Association was held at the Institution of Civil Engineers, Westminster, on the 16th and 17th of April last, at which Messrs. Vawser, Laws, Dunscombe, and Ellice-Clark officiated as examiners. At this examination fifteen candidates presented themselves; and of these, the following nine satisfied the examiners, and have received a certificate to that effect :—Messrs. J. A. Angell, H. Ashmead, H. G. Coales, W. C. Fenton, A. D. Greatorex, A. Harland, F. Osborn, E. E. Saunders, and J. W. Witts.

Arrangements are being made to carry out the second examination in Liverpool in October next.

Your Council, while expressing satisfaction with the success attending the first examination, venture to hope that many of the members of the Association will present themselves on future occasions to be examined. This will unquestionably tend to give confidence and encouragement to others, and so secure the success of this department of the Association's work.

Your Council have had under consideration the desirability of admitting gentlemen who have passed the examination into the Association, and recommend the following new Rule:—

"That candidates successful in obtaining certificates of competency at any examination under the auspices of the Association, and who are not otherwise qualified as members of the Association, shall constitute a class of graduates, and as such shall be entitled to attend all general and district meetings and to take part in the proceedings thereof, but shall not vote in the election of the Council; a graduate shall be furnished with a copy of the Minutes of the Proceedings on payment by him of an annual subscription of one guinea, and shall be transferred to the class of members when qualified according to Rule III. A graduate shall not be required to pay an entrance fee either on his becoming a graduate or on his transfer as member."

For the purpose of watching the interests of the Association in matters of legislation affecting its members, your Council have appointed a Parliamentary Committee. These are—

E. B. Ellice-Clark (Chairman), Messrs. Angell, Jones, T. De C. Meade, A. Parry, O. C. Robson, and W. H. White.

The Council recommend that the Parliamentary Committee shall be a standing committee to which other and analogous matters of detail can be readily referred, and the Council will from time to time make such alterations in the *personnel* of the Committee, and its duties, as seem most conducive to the best interests of the Association. This Committee has already had under its consideration the Public Health Act Amendment Improvement Expenses Bill, and has had several interviews with the promoters of that Bill, with the result that many of the amendments advocated by this Association were inserted.

The Council have not been able to mature the arrangements towards the attainment of a Royal Charter, which subject was brought before the last General Meeting, but both this and the Incorporation under the Companies Act have their frequent attention.

The Council recommend that two premiums in books of the respective values of 10*l.* and 5*l.* be given annually for the best original papers on some subject of professional interest to be approved by the Council. All premiated papers to be the absolute property of the Association, and may be published in the Proceedings.

The Council recommend that the next Annual Meeting be held in Leicester.

The PRESIDENT moved that the report be received and entered on the minutes.

Mr. C. JONES formally seconded the proposition, which was adopted.

The PRESIDENT then moved the following amendment of Rule III.:—

"That the Association consist of Civil Engineers and Surveyors holding chief permanent appointments under the various Municipal Corporations or Sanitary Authorities within the control of the Local Government Board, *or under the Metropolis Local Management Acts.*"

Mr. LAWS seconded the motion.

Mr. FOWLER and Mr. GORDON supported the proposition, which was unanimously adopted.

The PRESIDENT also moved the following amendment of Rule III.:—

"Civil Engineers and Surveyors holding *permanent* appointments *under any Public Authority within the United Kingdom,* or in the Colonies, or Foreign Countries, shall be eligible for election as Members, subject to the approval of the Council. The Council shall also have power to elect such Honorary Members as they may see fit."

Mr. COULTHURST seconded this.

Mr. WHITE proposed, as an amendment, to insert after the word "holding," in the first line, "other chief."

Mr. DE COURCEY MEADE seconded the amendment, which was accepted by the Council, and the proposition as thus altered was then unanimously adopted.

The PRESIDENT then moved the following modification of part of Rule V.:—

"The Council shall nominate one name for President, *three* for Vice-Presidents, &c."

Mr. PLATT seconded this, which was carried unanimously.

The PRESIDENT next moved the following addition to Rule V.:—

After the words "20th April in each year"—"*and in case the Members' nominations should not reach fifteen, the Council shall* *have the power to make up the total number of nominations to thirty.*"

It was explained that this recommendation was made, because only three nominations had this year been received from Members.

Mr. Laws seconded this.

Mr. Fowler moved and Mr. Spencer seconded as an amendment, "that these words be not added to the Rule."

On a vote being taken, the amendment was rejected by a large majority, and the original proposition was adopted, with only four dissentients.

The President then proposed the adoption of the following new Rule, as amended on the suggestion of Mr. Eayrs, who then seconded it:—

"That candidates successful in obtaining certificates of competency at any examination under the auspices of the Association, and who are not otherwise qualified as members of the Association, shall constitute a class of graduates, on payment of an annual subscription of one guinea; and as such shall be entitled to attend the general and district meetings, and to take part in the proceedings thereof, and be entitled to a copy of the Minutes of the Proceedings, but shall not take part in the election of the Council. Graduates shall be transferred to the class of members when qualified according to Rule III. A graduate shall not be required to pay an entrance fee either on his becoming a graduate, or on his transfer as a member."

The President, in reply to a question from Mr. Eaton-Shore, said that a graduate would be excluded from taking part in any discussions affecting the constitution of the Association.

The new Rule as amended was then carried unanimously.

The remaining portions of the Council's report were then considered, and on the motion of the President, seconded by Mr. Cregeen, were adopted.

Mr. R. Godfrey and Mr. Sidney Gamble were unanimously elected auditors for the ensuing year.

Mr. A. T. Davis, Mr. Price, Mr. Eayrs, and Mr. T. De Courcey Meade, were unanimously chosen as Scrutineers.

On the motion of Mr. Laws, seconded by Mr. Cartwright, the existing district Secretaries were appointed to act until the next meeting of their respective districts.

Mr. C. Jones proposed a hearty vote of thanks to the retiring President, which he was sure would meet with the cordial approval of every member of the Association. Though residing at a distance from headquarters, he was always at his post, and ready to do the best he could for the interests of the Association. During the year Mr. Vawser had been President, more Members had joined the Association from the district for which he was Secretary than in any previous year. Though he was vacating the Presidential chair, he was sure Mr. Vawser would still give them his valuable co-operation, counsel, and assistance; and by his fearless speaking—for he was a fearless speaker—bring the members of the Association into close contact with facts as they are. He had therefore great pleasure in proposing that they render their hearty thanks to the retiring President for his valuable services during the past year.

Mr. LAWS, in seconding Mr. Jones's proposition, observed that he would not attempt to add anything to what Mr. Jones had said. Although emphatically an Association President, Mr. Vawser had worked most cordially and thoroughly with the Council, and every member of that body would heartily endorse what Mr. Jones had said. The proposition was carried by acclamation.

The PRESIDENT ELECT then took the chair, and read his inaugural address.*

CHAS. JONES, *Hon. Sec.*
THOMAS COLE, *Secretary.*

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* This address, and the papers read at the meeting, will be found at the end of the volume.

Dr. STATEMENT OF RECEIPTS AND EXPENDITURE FOR THE YEAR ENDING APRIL 30TH, 1886. Cr.

RECEIPTS.	£	s.	d
To Balance at Bank (May 1st, 1885)	127	17	5
" Entrance Fees	26	5	0
" Subscriptions	205	16	0
" Subscriptions paid in advance	3	3	0
" Arrears	9	9	0
" Publishers' Sale of Proceedings	23	16	4
" Examination Fees	51	9	0
" Balance of Petty Cash due to Secretary	8	15	5
	£456	11	2

EXPENDITURE.		£	s.	d.
By Burnley Meeting		2	2	0
" Home District Meetings		2	18	6
" Nottingham Meeting		3	3	0
" Blackburn " (Report)		3	3	0
" Annual Meeting		10	10	0
" Blackburn Meeting (Expenses)		2	0	0
" Stockton "		2	4	6
" Stratford "		3	3	0
" Messrs. Cook and Hammond (Sundry Printing)—				
1st Account	£16 15 0			
2nd "	11 3 0—	27	18	0
" Secretary's Salary		60	0	0
" Petty Cash—Stationery and Sundries		10	4	2½
Postages, vol. xi.		5	10	6
" General		5	14	2½
" Circulars		7	6	6
" Messrs. Clowes (Printing vol. xi.)		104	4	6
" Bank Charges (cheque-book, &c.)		0	5	0
" Balance at Bank, May 1st, 1886		206	4	3
		£456	11	2

STATEMENT OF ASSETS AND LIABILITIES, APRIL 30TH, 1886.

LIABILITIES.	£	s.	d.
To Estimated Liability on vol. xii.	30	0	0
" Sundry Printing	20	0	0
" Secretary Balance of Petty Cash	8	15	5
" Outstanding Accounts	0	0	0
" Examiners' Expenses Estimated	25	0	0
" Balance	217	3	2
	£300	18	7

ASSETS.		£	s.	d.
By Balance at Bank		206	4	3
" Subscriptions in Arrear	£85 1 0			
" " less 50 per cent. bad ..	42 10 6—	—42	10	6
" Proceedings in Stock	£104 7 8			
" " less 50 per cent.	52 3 10—	—52	3	10
		£300	18	7

Examined and found correct, Albert W. Parry, } Auditors.
Sidney G. Gamble, }

May 13*th*, 1886.

Lewis Angell, *Treasurer.*
Chas. Jones, *Hon. Secretary.*
Thomas Cole, *Secretary.*

DISTRICT MEETING AT BLACKBURN.

August 28th, 1885.

Held in the Town Hall, Blackburn.

R. Vawser, M. Inst. C.E., *President, in the Chair.*

The minutes of the last meeting, held in the Lancashire and Cheshire district at Burnley, were read and confirmed.

Mr. S. S. Platt was unanimously re-elected as Honorary District Secretary.

SOME PARTICULARS OF THE MUNICIPAL AND SANITARY WORKS OF BLACKBURN.

By J. B. McCALLUM, Borough and Water Engineer, Blackburn.

The town of Blackburn was incorporated in 1851.

Population in	1801	11,980	Population in	1851	46,536
„	1811	15,082	„	1861	63,126
„	1821	21,940	„	1871	76,339
„	1831	27,091	„	1881	104,012
„	1841	36,629	„	1885	112,574

Blackburn stands 18th amongst the 28 large towns of England. The death rate in 1884 was 23·4 per 1000 of the population. The area of the borough is 6973 acres. The rateable value is 374,221*l.* General district rate, 3*s.* 2*d.* in the £. Borough rate (collected by overseers of the poor), 1*s.* 4*d.* in the £. Total, 4*s.* 6*d.* —Also collected by overseers of the poor—poor rate, 9½*d.* in the £; county rate, 4*d.* in the £; and registration expenses ½*d.* in the £.

Although the area of the borough is 6973 acres, only about 950 acres can be said to be contributing sewage to the public sewers. The daily dry weather flow is about 3,000,000 gallons. The Main Drainage works were commenced in 1856, but it was not until about 1861 the main trunk egg-shaped sewer, 6 feet by 4 feet, was completed under the supervision of Mr. J. Brierley, C.E. This sewer commences at Wensley Fold, near the Witton outfall works, and proceeds along Ainsworth Street (Witton) to Bridge Street, and under private land to Throstle Street, and then again under private land to George Street West; thence along Adelaide Street, Feilden Street, Lord Street West, to Victoria Street. Here the size is reduced to 5 feet by 3 feet 4 inches, and the sewer continues along Victoria Street and Church Street to Salford Bridge. The total length of the 6 feet by 4 feet sewer is 1840 yards, with a mean inclination of 1 in 330, and a discharging capacity of 2,300,000 gallons per hour. [*Note.*—The main sewers and storm overflows of the district are designed generally, so as to be adequate to discharge 0·25 of an inch of rainfall per hour on contributing area, plus ordinary flow of sewage contributed at time of construction with a margin for extension of sewage flow.] There are two storm-water overflows on the main trunk sewer—one at the outfall, and the other at the junction of Feilden Street and Paradise Lane.

The principal tributary sewers are—

At Bridge Street, a 2-foot barrel sewer.
,, Garden Street, a 15-inch earthenware pipe sewer.
,, Throstle Street, a 24-inch ,, ,,
,, George Street West, a 4-foot by 2-foot 8-inch egg-shaped sewer.
,, Leyland Street, a 6-foot by 4-foot ,, ,,
,, Feilden Street, a 3-foot by 2-foot ,, ,,
,, ,, ,, also, a 2-foot 6-inch by 1-foot 8-inch ,, ,,
,, Lord Street, a 4-foot by 2-foot 8-inch ,, ,,
,, Church Street, a 3-foot 6-inch barrel sewer.

Many of these sewers are provided with storm overflows into the nearest natural stream or river.

At the extension of the borough in 1876, it was found that a portion of the added area was at too low a level to admit of its sewage being received into the existing main outfall sewer. Mr. Bryan met this difficulty by designing a pair of hydraulic engines, placed in a chamber under roadway, actuated from the 6-inch water main. These pumps are capable of lifting together, 1,000,000 gallons a day, to the height of 20 feet. No attention is required, except oiling, &c., once a day.

In this instance, and wherever it seems convenient, the separate system of sewerage is adopted.

Ventilation of Sewers.—Owing to the hilly nature of the town, and fair amount of rainfall, the sewers generally are kept free from deposit without mechanical flushing; consequently little, if any nuisance is experienced from the prevailing open grate system of ventilation in streets. It is considered that what sewer gas is generated arises mostly from the lower levels; but it undoubtedly rises to some of the highest levels, rendering air disconnection from dwellings most requisite, and this is being insisted on.

The total amount spent up to the present time in main sewerage amounts to 229,151*l*. The Little Harwood and other outlying districts are now being main sewered at a cost of about 10,000*l*.

No municipal scheme undertaken by the Blackburn Corporation has, perhaps, been so difficult as that of dealing with the sewage of the borough. Compelled by an injunction to get rid of the sewage in a more scientific and less dangerous way than by turning it in its crude state into the river Blakewater, they had set them a task that seemed vast and responsible indeed. However, the Corporation did not shirk the responsibility, nor delay action in the matter; and in 1870 they made application for Parliamentary powers to purchase 1140 acres of land in the townships of Hoghton, Pleasington, and Samlesbury, with the result that after a severe fight, certain powers, so far as purchase of land was concerned, were granted. Under the previously existing circumstances, five large precipitation tanks had been constructed in the Witton district, the sludge from which, after being dried, was then, as now, disposed of to neighbouring farmers at a nominal sum. The tanks are 183 feet long and 18 feet wide at top, diminishing to 6 feet wide at bottom, and are 7 feet deep. Two tanks are used at once.

Not very long after this work had been carried out, it was decided to carry the effluent water from the tanks into the outskirts for the purpose of irrigation. As the result of this decision, a farm of some 179 acres in extent, situate in the townships of Pleasington and Hoghton, was obtained on lease from Sir Henry de Hoghton, at a very high rental, as compared with that of the land surrounding it (480*l*. is paid for 179 acres). About 100 acres of this farm lie quite too high for irrigation by gravitation, and the remainder is very hilly, having a fall of considerably more than 100 feet to the river Darwen. The effluent water from the tanks is gravitated towards the above farm, known as the Higher Park Farm, by means of conduits and an inverted syphon over 7000 feet long, opening into a tunnel near to the farm. The construction of this tunnel through lands belonging to the Priory at Pleasington gave rise to the noted Peduzzi arbitration case; the arbitrator awarding the plaintiff, in this instance, *more than he originally* *claimed.* The construction of the outfall works from the tanks to this farm was from the designs of Mr. Joseph Brierley, M. Inst. C.E., who most successfully carried out the work.

Finding the amount of land thus obtained inadequate for the needs of the borough, the Corporation subsequently purchased by arbitration 380 acres of the Petres estate, and they had to pay a high price. The net annual value of the land was about 580*l.*, and the award was very nearly 80 years' purchase. This arbitration was a most expensive one. A great many skilled witnesses in the country were engaged, and the printed minutes form a most formidable looking volume of some 1200 foolscap pages. The expenses, which fell upon the Corporation, reached a total of 13,500*l.*, which made the cost of the land come to rather more than 153*l.* per acre.

The Corporation afterwards purchased by auction, and by agreement, 97 acres of land at Samlesbury; and more recently the Uplands Farm. The total area of the Samlesbury farms is 510 acres, of which about 494 can be irrigated. The greatest difference of level on this farm is about 250 feet, and the range of elevation which the Corporation consequently command is about 200 feet. In connecting the Samlesbury Farm with the High Park Farm, the conduit had to be laid through the entire length of the farm, and many very heavy works had to be undertaken. These works were designed and carried out by Mr. F. Smith, the then Borough Engineer. The works were continued from this point to the new farms purchased by arbitration, by Mr. W. B. Bryan, M. Inst. C.E., the late Borough Engineer. In continuing this conduit to Samlesbury, four very deep ravines had to be crossed. In crossing the first of these ravines, the sewer, which is constructed of wrought iron, takes a leap down of from 80 to 90 feet in a shaft. From the bottom of this shaft a tunnel has been driven out of the hill-side at a height of about 40 feet above the river. A wrought-iron tube bridge, of three spans of 40 feet each, crosses the ravine (the sewage being at this point under very great pressure), and the conduit is continued under pressure for a considerable distance up the hill, the summit of which is tunnelled through. The next ravine is crossed by an embankment containing some 13,000 cubic yards of earth; and the two next by means of wrought-iron tubes, each of 40 feet span, the stream passing underneath these syphons. The conduit then contours the hill-side as far as the Sharples Farm, at Samlesbury. From this point the whole of the main conduits are of cast iron, and are under pressure. The water is turned on to the land from tanks, each tank being governed by a 6-inch sluice valve upon the pipes communicating with the main conduit. The sewage is applied to the land by means of open contour carriers.

The Corporation farm the Higher Park Farm themselves; but the farms at Samlesbury are let to tenants, who have the privilege of using just so much sewage as they please, and no more. The surplus is disposed of upon the Higher Park Farm, but it has been proposed to utilise the Darwen Side Farm as an area for intermittent filtration to purify the sewage not used on the other farms. The total expenditure upon the irrigation works up to the present time has been 129,328*l.* This includes the purchase and laying out of Samlesbury farms, and the cost of outfall works, settling tanks, and outfall sewer, and new farm buildings.

The yearly loss on the Higher Park Farm is about 600*l.* The income obtained from the Samlesbury farms is about 900*l.* per annum, paying a little over 1¼ per cent. on 70,000*l.* first cost. It is shortly intended to extend the sewage conduit so that the whole of the Samlesbury farms may be irrigated.

The tub system has played an important part in Blackburn in the past, if only in abolishing 5000 offensive middens. At a time when water was scarce it was a remedy that could be quickly applied, but it has proved a most expensive one. Attention was drawn to this latter fact by the rapid rise in the cost of the Sanitary Department, and in 1882 a careful investigation was made, and the conclusion arrived at that it was not economical to cart about fæces and urine when there was a system of sewers ready at hand into which to take the sewage. The water-closet system was thereupon adopted; all new outside closets being automatic flushing with seat action, waste-preventing cisterns with flush of 2 to 3 gallons (according to kind of cistern used), and hopper basins. Houses on the water-closet system are generally preferred by occupiers to those on the tub system. The writer ventures to point out that if the cost of excreta tub collecting is kept properly separate from ashes collection, as it ought to be, the cost of collecting tubs in some of the larger towns would be found to be astounding.

The Tipping-tank Waste-preventing Cistern.—One of the principal features peculiar to this cistern is the absence of a ball cock or float. The inlet valve is closed by the action of the tipping-tank or tumbler automatically tipping a little when full, and raising a lever. The lever also prevents tumbler discharging till handle is pulled. The outlet to flushing pipe being entirely free from obstruction, and the full flush taking place immediately the handle is pulled, the water has great power to cleanse out the w.c. basin and trap. The handle cannot be set for waste to take place; and the valve will suit any pressure. The cistern can also be used with seat action arrangement, in which case no water remains in it to be frozen.

Waterworks were first established at Blackburn in 1772, and belonged to some members of the Feilden family and the Archbishop of Canterbury. Two small reservoirs were made in the Pemberton Clough (now utilised as ornamental lakes in the Corporation Park), and these works were subsequently added to. The original pipes to the town were made of trunks of trees, bored through the centre. In 1844 the works were found so inadequate for the town supply, that a number of local gentlemen formed a company, and obtained powers to establish new works (1845). The old works were purchased from Mr. Joseph Feilden (1848) for 4000*l.* At this time a 5-inch iron main conveyed the water to the top of Northgate, and so on for distribution throughout the town in smaller iron and lead pipes, varying in size from 4 inches to 1 inch in diameter. There were at the time of purchase by the company, 5546 yards of pipes laid in streets.

The new company had engaged Mr. Bateman, C.E., in 1844, their engineer, and he was the author of the scheme approved by Parliament in 1845. The population at this time was 37,000, and the estimated daily requirement of water 810,000 gallons per day. The drainage area acquired for the use of the town was about 800 acres of moor land, situate in the townships of Yate and Pickup Bank and Oswaldtwistle; and this was estimated to yield 1¾ million gallons per day. It, however, never reached this. The first reservoirs constructed were (1845–7):—I. The Pickup Bank, capable of containing 31,000,000 gallons (level of overflow, 718·5 above Ordnance datum). II. The Guide, capable of containing 87,000,000 gallons (level of overflow, 642·3). III. The Hoddlesden Compensation Reservoir, capable of containing 62½ million gallons (level of overflow, 652·7 above Ordnance datum). The waters of the Tinklers Brooks and other streams of the gathering ground were impounded in the Pickup Bank and Guide Reservoirs—the connecting link being a stone conduit

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which picked up on its route the water belonging to the catchment area. From Guide a culvert was carried to a small service reservoir (now known as Old Audley), and thence into the town mains. Compensation to streams interfered with was given by buying up some small mills on tributary streams, and by the construction of a reservoir on the Hoddlesden Brook, to contain not less than 7,000,000 cubic feet, and of which 5 cubic feet per second, for twelve hours of working days, were to be discharged for five years after completion. If the reservoir performed this duty it was to be accepted as full compensation. The reservoir was finished in 1847, and at the end of the period of probation it was found equal to the duty required.

On the 9th of October, 1847, the new supply was given to the town—the mains laid being 10⅔ miles in length and varying in size from 12 inches to 2 inches.

In 1849, the Daisy Green Reservoir, containing 12 millions (level of overflow, 964·7), was constructed. From the time of the formation of company up to 1854, the consumption had steadily increased, until in this year it reached 900,000 gallons per day. Additional storage to the extent of 200,000 gallons was then provided by raising the embankment of the Guide Reservoir three feet.

The New Audley Reservoir, containing 13,000,000 gallons (level of overflow, 593·2), was made in 1856. In 1857, the consumption was still increasing, and special means were taken this year to prevent waste. In 1859 the consumption was 920,000 gallons per day. Endeavours were then made to obtain an additional supply from the Darwen Water Company, but the negotiations fell through, and Parliamentary powers were obtained in 1861 to enable the company to make additional reservoirs on the Hoddlesden Brook; and to convey surplus water from thence to a new reservoir called Fishmoor, holding 310,300,000 gallons—(level of overflow, 600 above Ordnance datum)—cost, including land, construction, and all charges, 50,000*l*. The only work constructed under the 1861 Act, was the Fishmoor Reservoir, which largely increased the town storage, and enabled the company to supply 1,600,000 gallons per day.

In 1875 the powers of the company were transferred to the Corporation, who purchased the works at a cost of nearly 342,000*l*. Immediately after the transfer to the Municipality in 1876, the Corporation set to work to supplement the existing supply by the promotion in Parliament in 1877 of a scheme for the obtaining of water from Bowland Forrest, in the West Riding of Yorkshire—a distance of over 20 miles. Mr. Bateman successfully engineered the bill through Parliament; and the identical gathering ground, over which powers were obtained, was a portion of the upper catchment area 6820 acres in extent, of the river Hodder reported upon twenty years ago by Mr. Duncan, C.E., and proposed to be then acquired for the supply of Liverpool. The Bowland scheme enabled the Corporation to impound the waters of the rivers Brennand and Whitendale for the town supply, and to construct, (i.) the Brennand Reservoir, capacity 143,000,000 gallons, estimated cost 46,000*l.* (level of overflow, 775); (ii.) the Whitendale Reservoir, capacity 142,000,000 gallons, estimated cost 39,000*l.* (level of overflow, 675); (iii.) the Lammack Reservoir at Blackburn, capacity 74,000,000 gallons, estimated cost 23,621*l.* (level of overflow, 550). Total cost of the works, estimated by Mr. Bateman, 422,000*l.* Compensation was to be provided by the construction of the Dunsop Compensation Reservoir, having a capacity of 650,000,000 gallons, estimated cost 107,000*l.* (level of overflow, 525 above datum). The scheme also empowered the Corporation to construct collecting conduits in the Brennand and Whitendale Valleys, and a conduit or pipe line leading to the town.

At the end of 1879, the Corporation instructed Mr. W. B. Bryan, M. Inst. C.E., the then Borough Engineer, to proceed with the partial carrying out of the works, with certain modifications. On the recommendation of Mr. Bryan, only the collecting conduits, intakes, and the laying of a 30-inch main to the town were proceeded with immediately; the existing reservoirs at Fishmoor and Guide being deemed sufficient storage for the time being. Land has been purchased for the construction of the Brennand and Whitendale Reservoirs, and they will be constructed when additional storage is required; land has also been purchased for the Dunsop Reservoir.

The compensation to be given to the streams amounted to 424 cube feet per minute during the whole of the 24 hours of every day in the year.* The construction, however, of the

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* The 424 cube feet compensation was based on the assumption that the annual rainfall on the mean of two consecutive dry years was 39 inches; of which 12 inches were deducted for loss, leaving the remaining 27 inches to be apportioned as follows:—9 inches (one-third) to the river, and 18 inches (two-thirds) to the Corporation. After a lengthened period of observation, it now appears safe to take 45 inches as the mean of two consecutive dry years; and

Dunsop Compensation Reservoir appeared to the Corporation to be such a gigantic affair, and so very uncertain as to ultimate cost, that a bill was promoted in Parliament last year which enabled the Corporation to abandon the construction of the reservoir, conditionally that they did not abstract water unless compensation to the extent of 150 cube feet per minute is being given to the river. Certain payments had to be made to some interested riparian owners, but the total cost of these payments and the cost of the Act is under 50,000*l.* The compensation water is measured below the junction of the rivers Brennand and Whitendale, at a place called the Clock House, and situate on the river Dunsop.

The collecting conduits in both valleys have been constructed above the top water-line of proposed reservoirs, and end at Screen Chambers, 775 feet above Ordnance datum. The water then enters the 30-inch mains, the two mains joining at Footholme. Provision is made by means of leap weir and other appliances, to prevent any dirty water getting into the town.

The pipe line, with valves, was laid by Messrs. Aird and Sons, the pipes being supplied by the Staveley Company. In its route from Bowland to the town, the large main passes the Hodder twice—at Thorneyholme on an iron bridge, and under at Sandalholme, where the pipes are flanged steel ones. The pipes again cross the river Ribble at Dinckley, over a stone bridge. Here the ordinary observed pressure is 225 lbs.

The total cost of the Bowland works, including compensation, has been 335,000*l.* The present consumption is from 2¾ to 3 million gallons per day, and there is a considerable surplus. During the past twelve months 400,000,000 gallons of water has been supplied to the Leeds and Liverpool Canal. The Bowland Main is capable of discharging 7,000,000 gallons per day into Fishmoor Reservoir. The main was first charged on September 4th, 1882. The total length of water mains now laid in the borough is 87 miles.

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allowing 14 inches for loss, there remains 31 inches available for use—9 inches (statutory quantity) being due to the river, and 22 inches to the Corporation. Only, however, a small quantity of the 22 inches can be collected, on account of the greater part being flood water rapidly running away. In estimating the yield of the gathering ground, it has been ascertained that the smallest recorded flow running off the gathering ground was on August 24th, 1884, when the yield amounted to 3,287,000 per day, or 365·2 cubic feet per minute. This is equal to 1·01 cubic feet per second per 1000 acres; and it seems safe to assume that half this quantity, say 0·5 cubic foot per second per 1000 acres, would flow off at the end of a long drought—or 180 cubic feet per minute, or, 1,620,000 gallons per day.

The highest levels of the town are supplied by pumping from a well and bore hole in the Millstone Grit. The supply to the well is supplemented by a pipe from Guide Reservoir. The water is pumped into the Park Reservoir, capacity 500,000 gallons (level of overflow, 722·8 feet above Ordnance datum). These works were designed and carried out by Messrs. Brierley and Holt in 1877, and cost 11,500*l.* Level of engine-house floor, 600. Level of delivery pipe from guide, 584.

The Twin Tipping-tank Water Meter.—This meter has lately been designed by the author, and is fixed at the Destructor Depôt, Audley. It is used for the purpose of measuring the water supplied to the Leeds and Liverpool Canal by the Water Committee, from their old gathering ground and works. It consists of a twin-tumbler, or double tipping-tank, working on a shaft, each compartment holding 100 gallons. The water is discharged into a well from a 12-inch pipe, whence it is distributed and delivered into tumbler over weir. The tumbler is so arranged that one compartment is always under weir to receive the stream. When the one compartment is full the action of gravity causes it to tumble over: and thus, while one is emptying, the other compartment is brought under weir to be filled in like manner. After emerging from tumbler, the water enters canal. The usual train of wheels and pinions (worked by an eccentric on shaft and a ratchet) records the quantity of water measured. Hydraulic buffers are introduced to break the fall of tumbler, and so avoid excessive wear and tear. This meter has now been working about a month, and is found to measure with absolute accuracy. It is capable of measuring over 2,000,000 gallons per day; but any size could, of course, be made. Where it is not necessary to maintain the pressure, this kind of meter would probably be found the most exact, as the water is actually measured, and it is simple and not liable to get out of order.

The Blackburn Gas Works were commenced in 1818, with a capital of 5000*l.*; the works were purchased by the Corporation in 1877. The total cost has been 602,000*l.*—with a production of 408,000,000 cubic feet per annum. The two works, together, cover an area of about 4 acres. Extensive additions and alterations have been carried out since the Corporation purchased the works; these have been designed, and executed under the superintendence of Mr. S. R. Ogden, the Gas Engineer. In the depth of winter there are 460 retorts in use, producing on an average 5000 cubic feet per retort per day. There are four gasholders (the largest 180 feet in diameter), with a total capacity of 3,201,000 cubic feet. The maximum daily consumption is 2,500,000 cubic feet; and the minimum 500,000. The average quality of gas supplied to consumers is 20 candles. Last year the sum of 6000*l.* from the gas profits was handed over to the Water Department, and this year a sum of 5000*l.*

Streets.—The length of roads in the borough just amounts to 100 miles—46 miles being paved, 31 miles macadamised, and 23 miles unpaved (streets laid out and partially built upon).

Haslingden or other local sets (costing delivered at Blackburn 10*s.* per ton, and paving 3·78 square yards) are used chiefly, and in all cases where adjoining owners are called upon to pay. In some of the leading thoroughfares Dalbeattie granite sets (costing from 25*s.* 6*d.* to 27*s.* 6*d.* per ton—according to dressing—and paving 4·30 square yards) are used, and paved over a 6-inch Portland cement concrete foundation. It is considered that in thoroughfares with large traffic, the Dalbeattie or similar sets (such as Newry, Ireland), properly laid on a concrete base, will eventually prove most economical as regards first cost and annual maintenance. These sets have been laid with a longitudinal gradient of 1 in 14 and a cross fall of 1 in 36, without accident or serious complaint as to slipperiness.

The ordinary macadamised roads are chiefly coated with Clitheroe limestone, costing delivered at Blackburn in "cob" 2*s.* 7*d.* per ton, and when broken 3*s.* 9*d.* per ton. The more important of the macadamised roads are coated with Penmaenmaer rock or stone of the Cumberland Road Metal Company, costing in "cob" 8*s.* per ton, and when broken 9*s.* 9*d.* per ton.

The steepest gradient of macadamised roads in Blackburn is 1 in 6·03, and of paved roads 1 in 6·05.

Private Improvements.—The cost of Private Improvement Works, repayable by owners of property, and carried out by the Corporation during the past few years, has been as follows:—

1880–1	9,800*l.*
1881–2	10,300*l.*
1882–3	16,100*l.*
1883–4	17,300*l.*
1884–5	24,200*l.*

The average cost to owners of property in 12 yards wide streets for excavating, hand-pitching, paving, grouting with pitch and tar and chippings, and with 12-inch wide curbs, and 3-inch thick flags, is 1*l.* 19*s.* 6*d.* per lineal yard of frontage; and including 12-inch pipe sewer an extra 5*s.* 6*d.*; making a total of 2*l.* 5*s.* per lineal yard of frontage.

Public Improvements.—The chief public improvement that has taken place recently is that known as the Salford Improvement, costing 45,000*l.* This consisted of bridging over the river Blakewater, pulling down old property, and forming wide streets in the central part of the town. Some of the property cost in purchase as much as 10*l.* per square yard. A not unimportant part of this improvement forms the approach road to the New Passenger Station now being built by the L. & Y. Railway Company at a cost of 100,000*l.*

Building Regulations.—The chief of these are, that the total area of a dwelling site shall be at least 84 square yards, of which 20 square yards shall be open space. The back roads are 4 yards wide, beginning and ending in a 12 yards wide street. Height of rooms 9 feet; 9-inch division walls carried up to slates.

In new buildings an air disconnection and water trap are insisted upon between the inside of dwellings and the sewerage system. In most of the existing cottage houses (especially those uncellared) there is no immediate connection with the sewer; but in the better class of houses a water trap is too frequently the only protection against the entry of sewer gas into a dwelling. During the past few years, however, many owners and occupiers (who consider it their duty to make it their business to ascertain that the houses they and their families live in are properly disconnected, by an air space, from the sewer) have caused the necessary works to be carried out to remedy this. Where it cannot be avoided, no objection is made to the making of an air disconnection in the roadway.

Tramways.—The tramways, belonging to a company, are laid from a central portion of Blackburn to the borough boundary of Over Darwen—a distance of 2½ miles; they then proceed through the chief part of Darwen. The gauge is 4 feet; and by the clauses of the Act authorising construction, the company are bound to repair the whole of the road traversed if steam traction is used. An agreement, however, is made by which only a width of 11 feet—including tramway—is repaired by the company.

Bridges.—Bridge construction forms by no means a small item in the public improvements of Blackburn. Many new structures have been of late years erected over the rivers Blakewater and Darwen, and also over the Leeds and Liverpool Canal and Railways.

The chief works constructed of recent date are—the Ewood Bridge and approaches, costing 4400*l.*; the Havelock Bridge and approaches, costing 3000*l.*; and the covering of the river Blakewater at Salford, which, including purchase of property and formation of improved thoroughfares, has cost 45,000*l.* Besides the above, many bridges have been built and widened. The paving of the river Blakewater has cost up to the present 7600*l.*; it is shortly intended to pave the whole of the remaining length yet unpaved, from Witton up to the junction of the river Blakewater with the Little Harwood Brook, above Cob Wall.

Expenditure in Highways and Drainage Department.—This department is the shop-keeper, and supplies all other departments. All material is obtained by annual contract in accordance with specifications, and signed samples kept at store-room. It is open to any member of the council to see at any time that materials being delivered are in accordance with signed samples. All material delivered, is weighed or measured in and out of store-yard; and stock is taken once a year by the Borough Treasurer, and compared with material used on public works or charged to private individuals, and traced to an end. In addition to this a private return is made to the Borough Engineer (as an additional check) by the local agent of Railway Company, of goods delivered to the Corporation store-yard.

A printed price book is got out annually to make it an easy matter to check accounts. Materials of all description are included in this book, from a box of matches to the more expensive materials used by a Municipality.

In order to keep the annual expenditure within the estimate, a chart is kept up by the bookkeeper showing the weekly expenditure in labour and material affecting the general district rate. As much work as convenient is done during the summer months, so as to be able to retrench if necessary during the last quarter of the financial year, to keep within estimate.

Blackburn Park was opened in 1857. It covers an area of 56 acres, and cost 19,700*l.* It is traversed by a stream of pure water and contains two ornamental lakes—formerly the Town Water Supply reservoirs. The Park is naturally well adapted for the purpose it is used for; and being close to the centre of the town, it is a favourite resort of the inhabitants.

The Audley Recreation Ground (33 acres) on the eastern side of the town is in course of construction. It is intended to spend 10,000*l.* in forming, fencing, and laying out. Plans have been prepared showing an ornamental lake of 4½ acres for boating and skating, bicycle track (20 feet wide—⅓ of a mile in length), large open spaces for games, a carriage drive, and several ornamental walks.

The Town Hall and Central Police Station were erected in 1856, and cost over 30,000*l.* It covers an area of 2617 square yards, and contains—Assembly room, 115 feet by 50 feet, capable of seating 1200 persons; council chamber, 44 feet by 23 feet 6 inches; large police court, 54 feet by 35 feet 6 inches; small police court, 35 feet 9 inches by 24 feet 3 inches; mayor's parlours; town clerk's offices; borough treasurer's offices; magistrates' clerk's offices; chief constable's offices; sanitary inspector's offices; 18 cells for prisoners, and other minor offices.

The Municipal Offices were built in 1880, and cost 8330*l.* They cover an area of 406 square yards, and contain offices for the borough and water engineer, gas engineer, water manager, and rate collectors. In the basement is a testing and fitting shop belonging to the Water Department.

Besides having the ordinary communication with the Lancashire and Cheshire Telephonic System, there is also a Corporation Telephonic Exchange, whereby all the Municipal offices and establishments are brought into direct communication.

Markets.—General market, erected 1848; size, 186 feet 6 inches by 109 feet 6 inches; area, 2253 square yards; cost, 8000*l.*

No. 2 Market, erected 1872; size, 74 feet by 80 feet; area, 657 square yards; cost, 8288*l.*

Fish Market, erected 1874; size, 80 feet by 30 feet; area, 264 square yards; cost, 600*l.*

Uncovered Market; area, 12,400 square yards; cost (including purchase and demolition of property for the purpose of increasing open space), 30,000*l.*

Total revenue, 5700*l.*

On the top of the Market Tower is a time ball worked from Greenwich Observatory. The ball falls daily at 1 o'clock.

Annual payment to Post Office for the service, 32*l*. The same current fires the time gun at store-yard.

The Free Library and Museum was erected in 1874, and covers an area of 1000 square yards; it cost 11,500*l*. There are three chief departments; the Reference Library, the Lending Library, and the Museum, besides a spacious reading room for select papers and periodicals. The total number of books contained in the library is over 30,000. There is a varied collection of articles in the museum, including some good pictures, the nucleus of an Art gallery.

The public baths were built in 1868, and extended in 1884, at a total cost of 7756*l*. They cover an area of 2350 square yards. The accommodation provided consists of a first-class swimming-bath, 60 feet by 34 feet, varying in depth from 6 feet 6 inches to 3 feet 6 inches, with 31 dressing-boxes; a second-class swimming-bath, 59 feet by 33 feet, of similar depth, and with 46 dressing-boxes; 29 slipper-baths for men, and seven for women. Special times are arranged for use of both swimming-baths by women during summer months.

The Fire Police Station covers an area of 2126 square yards, and cost 6280*l*. A residence for the superintendent inspector, and 16 cottages for firemen are provided. There are two steam fire-engines (by Shand, Mason & Co.), one manual engine, two fire-escapes, and two hose carriers. A club room (containing a full-sized billiard table) is open to the use of the members of the brigade and police force. There is also stabling for eight horses,—four horses always being ready to go out.

In connection with this department, there is a volunteer brigade of 12 members. All paid members and volunteers are in direct telephonic communication.

The Blackburn Exchange is the property of a private company, and was erected in 1865 at a cost of 10,000*l*. It covers an area of 1553 square yards, and contains the exchange room, 128 feet by 53 feet, capable of seating 1500 persons. There is also a well-supplied reading-room; and a lecture room, 66 feet by 30 feet, capable of seating 400 persons. There is a telephonic call office, telephonic chamber for use of members, and other suitable accommodation. The chief design of the building is to facilitate the local trade in cotton yarns; and there is a weekly market on Wednesdays.

The County Court Offices were erected in 1862 at a cost of

3000*l*., and occupy an area of 660 square yards. The court-room is 49 feet by 29 feet 9 inches, and there is the usual accommodation for the registrar and his staff.

The County Police Offices were erected in 1873, on a site of 1780 square yards, and cost 4000*l*. (including furniture, 400*l*.). It contains a court-room 49 feet by 40 feet; magistrates' room, superintendent's house, two constable's houses, offices, stables, and four lock-up cells.

The Corporation Store Yard covers an area of 17,526 square yards, and is used jointly by the Highways and Scavenging Departments. There are stables for 50 horses; residences for storekeeper and scavenging superintendent, blacksmith's shop, wheelwright's shop, carpenter's shop, mortar mill, disinfecting chamber, mess-room for workmen, stone-breaking machine and steam crane, cement store-room, materials store-room, locomotive shed, general offices, railway sidings from L. & Y. R. Co.'s system, and a platform for time gun (fired daily at 1 o'clock by current from Greenwich). Over two acres of land have been acquired near Daisyfield railway station for the purpose of additional store-yard accommodation when required—annual ground rent 103*l*. 18*s*. 5*d*.

The Cattle Market adjoins the store-yard, and contains an area of 9151 square yards. The cost was 8635*l*.; this is exclusive of land, which is held (as well as land occupied by store-yard and public abattoirs) on perpetual chief rent from the Lord of the Manor. The annual revenue is only 126*l*. The accommodation provided, includes a siding from railway; 43 cattle pens; 64 sheep pens; 12 pig pens (under cover); and 24 miscellaneous pens (under cover).

The public abattoirs, adjoining the Cattle Market, contain an area of 2138 square yards. The buildings cost 5359*l*., and the annual revenue is 361*l*. The following extensions are about to be made, at the estimated cost of 2000*l*., on spare land now comprised within the area of the Corporation store-yard, viz.—seven slaughter-houses, 30 feet 6 inches by 16 feet; three slaughter-houses, 30 feet 9 inches by 28 feet 4 inches; and one house for keeper.

The Audley Destructor Depôt has cost (including land, 15,086 square yards) 10,724*l*. There is a four-cell Fryer's destructor, with chimney 35 yards high. There are 111 yards of canal wharfage, 42 yards of which is covered. Stabling is provided for three horses, also cooperage tub store, and mess-room for workmen.

Within the area occupied by the Audley Destructor, there was erected in June, 1881, a wooden structure one storey high (occupying 482 square yards), for use as a smallpox hospital. There is accommodation for 20 patients. The building was erected in 10 days, and cost 850*l.*

The Infirmary stands on a piece of land 8 acres in extent; the building was commenced in 1858, and has cost (with recent additions) about 30,000*l.* There is accommodation for 87 patients.

The Union Workhouse was erected in 1864, and has cost (with recent additions) 56,600*l.* It is built on a site of 30 acres, with accommodation (when additions are complete) for 1500 inmates.

Although the Cemetery is not strictly speaking a Corporation establishment, it is managed by an elective Burial Board. It was opened in 1857, and covers an area of 41 acres. The cost of land and boundary walls, forming, and constructing three mortuary chapels, was 19,000*l.* The revenue is 1758*l.*; and the annual number of interments 2481. Total number of interments since opening, 56,739.

In conclusion, the writer must perhaps now apologize for the length of the paper. He thought it would be better when digging into the subject, to dig as deeply as possible, so as to place on record such information as he was enabled to gather, — information calculated to be useful hereafter to members of the Association and others.

In welcoming the members of the Association to Blackburn, the writer would remark, that for many years past there has prevailed in the town a spirit of true municipal progress. Though Blackburn—like most other manufacturing towns—cannot be said to be altogether prepossessing in general appearance, it still preserves many examples of the pristine beauty of its natural situation. First impressions are said to be lasting, and as most visitors to the town arrive at the L. & Y. Railway Station (described by a writer as "a combination of all that is inconvenient and dangerous, and characterised by the dirty dinginess of its appearance"), it is only to be expected that the town is not generally credited with the importance it deserves, either from a municipal or commercial point of view. All this, however, is about to be changed, and the new station now being constructed will be all that could be desired; and the necessary approaches have already been constructed by the Corporation.

Whilst, however, the Railway Company have been long in providing proper station accommodation for the town, the town on the other hand has been foremost and most energetic in providing for the wants of the Municipality. All the usual municipal works are in existence, and nothing is wanted but good trade to ensure the economical extension and further development of the same. The suburbs of the town are most healthy and beautiful; and it is a fine sight, to view on a clear night from adjacent heights, the lines of lighted streets and mill buildings. The Corporation has done much to restore the stream known as the river Blakewater (which traverses the town through a paved channel) to its former purity; and although not yet a trout stream as of yore, the pollutions are of a minor character, and are doomed to actual extinction at an early date.

Finally, the writer suggests that it is a matter of special congratulation, that this Meeting is attended by the President (Mr. Vawser) and Mr. J. Brierley. Both these gentlemen are ex-officials, who have been enabled by their abilities and fortune to leave the turmoil of municipal appointments, and engage in private practice. Their presence here to-day shows a kind desire to assist their former brethren in the arduous work they are called upon to perform.

DISCUSSION.

The President: There is some very interesting work in connection with the siphon for conveying the sewage down these gorges. Mr. McCallum has mentioned them; but I shall be glad if he or Mr. Brierley, who constructed them, will give us more particulars respecting them. Do these siphons keep clean? I think it would be useful to have details of this for reference.

Mr. Brierley: I do not know that I can supply any farther information than is embodied in the general description Mr. McCallum has given. The siphon in the first instance was 24 inches in diameter, extending for a length of about 7000 feet, having a dip of 35 feet to the level of the river bed, and then rising to the mouth of the tunnel. The other siphon, constructed firstly under the superintendence of Mr. Smith, and afterwards of Mr. Bryan, presents the rather curious feature of a direct, vertical drop of 80 or 90 feet, and then a considerable ascent. I do not know that there is anything particular about the other siphon; but they seem to have acted with perfect success. There is no difficulty as to keeping clean, because the sewage has first been passed through the settling-tanks, and there the solids are removed which might affect the passage of the sewage through these siphons.

Mr. McCallum: There is a storm overflow where we can turn the crude sewage into the river, but it has not been necessary to do this more than once in the course of the last three years.

Mr. Fowler: What is the depth of the borehole, and the size of the pipe? also the width of the street where the total cost to owners was 2*l.* 5*s.* per lineal yard of frontage? Do you find it economical to have a storeyard and trans-ship the stone, and then cart it to the works? in Salford I found it very much more costly.

Mr. McCallum: The well is 30 feet deep, and the borehole 200 feet deep and 21 inches in diameter. The width of the street was 12 yards. It might not be so economical if every man were an honest man; but we find it better to take stores in and keep an accurate record, in order to check consumption. We get most materials by rail, so that it really does not make so much difference.

Mr. S. S. Platt: There is one question I should like to ask respecting the cost of new streets. Mr. McCallum says they have "grouting with pitch and tar, and chippings." I should like to know whether they charge the cost of this upon the owners of adjoining property?

Mr. McCallum: Oh, certainly.

Mr. Platt: It is the first place where I have ever heard of this being done. It is very desirable, I admit, from the Corporation point of view, but it is a heavy expense to put owners of property to. I saw at Burnley they proposed to do this, but there the Corporation paid the difference. I do not know whether you have any special powers at Blackburn.

Mr. De Courcy Meade: I should like to ask Mr. McCallum the mode adopted for collecting the money from owners of adjoining property for private street improvements? also whether a loan is raised to pay the contractor, and if so, for how long the money is borrowed and how it is repayable? or whether the contractor has to wait until the work is completed, and the money has been collected from the owners?

The President: Before Mr. McCallum replies to these questions, I should also like to ask him how much water is used for working the hydraulic engines for pumping the sewage, mentioned in the paper, and what becomes of it? It is a very ingenious way of raising the sewage, provided it does not lead to too great a loss of water. With reference to the question Mr. Platt has just put, as to charging owners of adjoining property with the cost of grouting with pitch and chippings, when I was in Warrington it was the practice there to pave private streets with granite 4-inch cubes, generally on a foundation composed of stone, and afterwards to grout the joints with tar, and the whole of the cost was paid by owners of property. Of course owners of property naturally object to pay anything, but the subject was discussed and thoroughly well thrashed out, and I believe the arrangement gave general satisfaction, both to the owners of property and to the ratepayers. A large portion of Mr. McCallum's paper is devoted to the cost of the sewage works, and those who are not acquainted with the history of Blackburn will learn some very interesting facts from it. It appears that the Corporation have suffered very severely at the hands of landowners, and have had to pay considerably more than the ordinary market value of the land. We of course have nothing to do with politics, but if any alterations are made in the land laws, there should be some provision to enable corporations to acquire land for public purposes at a fair value. It appears from Mr. McCallum's paper, that the cost of land acquired by the Blackburn Corporation has been at least 50 per cent. more than its ordinary market value: it seems hard that the present generation and posterity should have to pay this excessive price. I am exceedingly glad to find that it is the experience of Blackburn that it is not desirable to maintain two systems of night-soil removal; and that the tub system having been found expensive, and otherwise objectionable, has been superseded by the water-closet system, which has come into general use. I was not aware, until Mr. Brierley told us just now, that the sewage was cleansed before it passed through the siphons. It had always struck me as surprising that a siphon with a depth of 75 feet and upwards, and on a comparatively flat gradient and consequently with a very small velocity, should keep itself clean, because I knew that sewers constructed under more favourable circumstances often got choked up. Many of the things described by Mr. McCallum we shall see during our visit to-day, and I very much wish that we could have had the discussion afterwards, as you generally desire to know a great deal more about these things when you have seen and inspected them. It appears that, in Blackburn as in other places, wealthy people enjoy the doubtful advantage of having sewer gas laid on to their dwellings. Of course if people like the luxury of sewer gas and water-closets, they must have it; but I hope that here and elsewhere, some means will be devised for remedying this source of peril before we have a visitation of cholera, which possibly may reach us next year. If any one has anything further to say, I shall be glad if he will say it now: we have a great many interesting things to see, and in the course of half an hour we must be on our way to see them. We are all very much obliged to Mr. McCallum for his very interesting paper, which must have taken a great deal of time to prepare.

Mr. Thorburn: There are just two questions which I should like to ask. One is, whether the outfall sewers are occasionally flood-locked, or are they always free and open at the outlet? The other is, what regulations you have in Blackburn with respect to breaking the continuity of house-drains? These are the two chief points that occur to me at present.

Mr. McCallum: As to the macadam and grouting, we have charged it to the owners for a considerable time, and no complaint is ever made about it. So far as I know respecting private improvements, we have not lost any money on account of them. In fact, by allowing the accounts to stand over for a time, and charging 5 per cent., we get sufficient to pay the collector's salary. The water which works the hydraulic pump is wasted. The estimated value of it is 20*l.* per annum, and that amount is charged to the Sewage Department for it. Our outfall sewers are not flood-locked in the way that Mr. Thorburn means, but of course they are under considerable pressure in different parts of the town during storms. With respect to sewer disconnections, I do not know that we have any special local powers, but we make it a rule that the drainage of the inside of a house is not connected in any way with the sewer. We use Pott's trap as being a good example of an air disconnecting chamber.

Mr. Stevenson: I think Mr. McCallum has not answered the question put by Mr. De Courcy Meade—how do you get the money for new street making? Do you borrow it; and if so, for how many years? Supposing a surveyor wishes to lay out 5000*l.* or 6000*l.* on street improvements, the usual course is to obtain the sanction of the Local Government Board to borrow the money for two or three years, and then extend the time for payment of the money by the owners. I am now laying out 10,000*l.* in my district for street improvements, and the contract is to be finished in six months, and the work is to be kept in repair for another six months; and by that time—within the year—we hope to get the money in. The difficulty with a corporation or local board is to have a sufficient balance at the bank from ordinary sources to pay for private street improvements as the work proceeds. As a rule, local boards have no such surplus funds available for the purpose. We had a Local Government Board inquiry about borrowing the 10,000*l.* we are expending; but after we obtained the sanction of the Board, we thought it better to defer payment for twelve months and endeavour to get the money in by that time. Then I should also like to know as to the different expenses charged to the private owners.

Mr. McCallum: I can hardly give you details as to where the money comes from for private improvements; but we have authority under local Act to pay for any works of this nature out of the General District Fund. I should not like to say what we get out of the work; but we do not lose anything; we put sufficient profit on the cost of the materials to fully make up for the haulage, getting in the money, and the engineering charges. We take good care not to lose anything, but, at the same time, we do not desire to make any profit out of the owners.

Mr. Stevenson: Do not you have to get the sanction of the Local Government Board before you can borrow the money?

Mr. McCallum: No; we have as little to do with the Local Government Board as possible. There have only been two inquiries held by the Local Government Board during my term of office. The work is done under a special Act, and we dispense with the Local Government Board.

Mr. Thorburn: I am somewhat surprised that gentlemen holding appointments under corporations and local boards in the capacity of engineers and surveyors should ask such questions as these. There are various ways of making and completing streets and private improvements chargeable to frontagers. In Birkenhead the Corporation are not compelled to go to the Local Government Board for authority to borrow or take up a loan to carry out this class of work, as fortunately they have a clause in a local Act which enables them to charge 5 per cent. on the cost of the work in respect to the additional cost incurred by the staff of the engineer, and for the cost of the engineer in superintending such work. During the last four years there have been over 100 streets made, and last year there was a credit to the Borough Surveyor's department of about 1200*l*. In addition to this, there is the usual 5 per cent. on the cost during the time allowed in the notice and the period that elapses before payment is made by the frontagers. The Corporation advance payments to contractors out of their funds during the execution of the works. I should say that all the work is done by contract. The contractor is paid monthly up to 80 per cent., 15 per cent. being paid at the end of three months, and the balance at the end of six months after completion. We have occasionally lost a little money, but upon the whole I think the Corporation clear their way in respect to this class of work.

Mr. LAWS: I think there is a vote of thanks which should be moved, and that is a vote of thanks to the Mayor and Corporation of Blackburn for allowing us the use of this building for our meeting. It is very gratifying when local authorities afford us facilities for meeting and discussing various matters, which are of greater importance to them than to ourselves. I am glad to be the means on this occasion of asking you to give a vote of thanks to the Mayor and Corporation of Blackburn for their kindness to us on this occasion.

The PRESIDENT: Before I submit the vote of thanks Mr. Laws has proposed, I may just say that this is the second occasion that we have visited Blackburn. We came here several years ago, and, by the kindness of the Mayor and Corporation of that day, met in this hall, and visited the gas and sewerage works. We were also honoured with a visit from the Mayor, and the Town Clerk was with us the greater part of the day.

The PRESIDENT then put Mr. Law's proposition, when it was unanimously adopted, and Mr. McCallum was requested to convey the thanks of the Association to the Mayor and Corporation.

Mr. THORBURN: I beg to propose that the best thanks of this meeting be given to Mr. McCallum for the very valuable and interesting paper just read to us. Though he has not been many years in Blackburn, Mr. McCallum has always kept a thorough grasp of his work; he has followed up the work of his predecessors in the way they commenced it, and I have no doubt that the Corporation find in him a valuable and efficient servant.

Mr. DE COURCY MEADE: I have great pleasure in seconding this, as I am sure, after hearing Mr. McCallum's interesting paper, we shall all go back home wiser than we came. The discussion has brought out a very interesting fact for local board officials—that in two towns, where there are private Acts of Parliament, the Corporations are enabled to charge all the expenses for new streets upon the owners, and nothing falls upon the general district rates. I am sorry to say that is not the case with local boards, and at Hornsey we are at considerable loss. We have made some 110 roads, and I think we are out of pocket some 4000*l.* Mr. Dawson, I believe, will admit that it is the same in his district.

The resolution having been carried, Mr. McCallum briefly returned thanks, and the meeting separated.

After luncheon, the following places were visited and inspected:—Blackburn Park, Free Library and Museum, Town Hall and Municipal Offices, the Exchange, the Markets, Public Baths, Corporation Storeyards and Workshops, Public Abattoirs and Cattle Market, Audley Destructor Depôt, Water Supply to the Canal, Audley Recreation Ground, and the Fishmoor and Guide Reservoirs. In the evening the Members dined together at the White Bull Hotel.

DISTRICT MEETING AT BOURNEMOUTH.

October 17th, 1885.

Held at the Town Hall, Bournemouth.

Mr. R. Vawser, *President, in the Chair.*

Mr. O. C. Robson was re-elected Honorary Secretary for the Home Counties District.

The following paper was read and discussed:—

THE RISE AND PROGRESS OF BOURNEMOUTH AND THE PUBLIC WORKS IN CONNECTION THEREWITH.

By G. R. ANDREWS, Surveyor to the Bournemouth Commissioners.

It is with very great pleasure I have the honour to welcome the Members of this Association to the urban district of Bournemouth, which is governed by an Act which received the royal assent 14th July, 1856, and which was chiefly obtained by the exertions of my predecessor Mr. C. C. Creeke. At that date the district comprised an area of 1139 acres 2 roods 8 poles, within a circle the radius of one mile, the centre being the front door of the Belle Vue Hotel; with a population of about 950, with 185 houses, and a rateable value of 5653*l.* In 1876 the Commissioners applied for and obtained a provisional order to extend the district eastwards, comprising an area of 532 acres 3 roods 14 poles; and in 1884 the Commissioners applied for and obtained a provisional order to extend the district on the east, west, and north sides thereof, comprising an area of 987 acres 3 roods 38 poles; making a total of 2660 acres 2 roods, the present area of the district, with an estimated population of 24,500 and 3134 houses, with a rateable value of 201,823*l.*

The Bournemouth district is chiefly table-land, averaging 126 feet above mean sea-level, and has for drainage purposes three distinct watersheds, viz. the valley of the Bourne, the valley of Boscombe Chine on the east, and the valley of the Alum Chine on the west. The whole of the sewerage works are constructed by gravitation, and thence discharged into the sea, by means of three outfalls.

Sewers.

In the first or original scheme of sewerage works, viz. the central sewerage works for Bournemouth, Mr. T. Hawksley was consulted, and the works were carried out by my predecessor Mr. C. C. Creeke (now a member of the Board), which consist of brick sewers for the main lines, with stoneware pipe sewers for the collateral lines and the branches which did discharge their contents for a distance of 700 feet into the sea by means of a 15-inch cast-iron outfall sewer. At that time the houses of Bournemouth did not extend much on to the table-land, but were confined to the then small area of Bournemouth, viz. the valley of the Bourne, and the sewers were extended from time to time with the growth of the town, by my predecessor and myself.

At the time of the extension of the district eastwards in 1876, as before mentioned, that distinguished engineer Sir Joseph W. Bazalgette was consulted, and he prepared a drainage scheme for the eastern inland works, and also for an intercepting sewer to be carried along the foreshore with an undercliff drive from the pier to Boscombe, thence with a cast-iron outfall out to sea about 1800 feet and into 24 feet depth of water; those works, with the exception of the intercepting foreshore sewer and undercliff drive, were with some modifications carried out under the direction of the Board.

In May 1879, finding the then 15-inch central outfall sewer not carried sufficiently out to sea, I was instructed to prepare plans and sections for a new central outfall at or near the present one. I carried out those instructions, which met with the approval of my Board and the Local Government Board Inspector: the works were afterwards carried out under my supervision with the aid of a diver, and the outfall has since acted in a most efficient manner for the purpose for which it was originally intended. In the outfall scheme I provided 18-inch cast-iron pipes 2004 feet in length out to sea, into 24 feet depth of water; the pipes are secured to the bed of the sea with screw piles and iron bands: the outfall sewer has a fall of 24 feet in its length, or equal to a gradient of 1 in 58, and is capable of discharging in the twenty-four hours 7,092,000 gallons, or in eight hours 2,364,000 gallons, equal to the requirement of a population of 49,000 persons, at the rate of 50 gallons per head per day. About the middle of 1882 the Commissioners were advised that it was impossible for the outfall to work without a flushing tank to hold 12,500 gallons of liquid matter, and were further advised to construct a flushing tank 100 feet long and 10 feet diameter to hold 12,500 gallons of sewage, to project the sewage into the sea. I strongly opposed this scheme (*Hear*, *hear*), and provided an alternative scheme, by which the outfall is now flushed every forty minutes with 21,500 gallons of fresh water from the brook (these works cost only 48*l.*), which scheme I propose showing you to-day. Since that time the outfall has been extended 600 feet further out to sea, making a total of 2604 feet, and into 36 feet depth of water.

In June 1879 the Commissioners instructed me to prepare a scheme of sewerage works for the western part of the district: at that date only twenty-four houses required a sewer. It was thought advisable to take the outfall as far west as possible, so as to enable to drain Westbourne, which was then outside the Commissioners' district. In the scheme I provided 1200 feet of 9-inch cast-iron pipes carried out to sea, into 24 feet depth of water, secured in the bed of the sea with screw piles and iron bands. Knowing that so small a quantity of sewage would not keep the outfall self-cleansing, I provided a large flushing tank to flush the proposed outfall; but through the opposition of the landowner before the Local Government Board Inspector, the flushing tank, which I considered the *backbone* of my scheme, was taken out, and much against my advice too; the result was the outfall got stopped, and the Commissioners were obliged, under the advice of Mr. Baldwin Latham, to have a flushing tank similar to that provided by me in my original scheme: since the tank has been completed, the outfall has acted in a most efficient manner. This outfall is capable of discharging in twenty-four hours 1,357,920 gallons; or in eight hours 452,640 gallons, and is equal to the requirements of a population of 9052 persons, at the rate of 50 gallons per head per day. The drainage of Westbourne is discharged through this outfall, and is now within the district of the Bournemouth Commissioners.

The Boscombe or eastern outfall was completed in July 1880, and is carried 1370 feet out to sea, into 24 feet depth of water, and consists of 30-inch cast-iron pipes, secured to the bed of the sea with screw piles and iron bands, and is capable of discharging in the twenty-four hours 21,212,660 gallons, or in eight hours 7,070,886 gallons, and is equal to the requirements of a population of 141,417 persons, at the rate of 50 gallons per head per day, so that we have in the three outfalls sufficient capacity for the total requirements of 200,272 persons.

The total length of sewers within the district, including the outfalls, is about 35 miles, consisting of brick sewers 3 feet by 2 feet and 2 feet 6 inches by 1 foot 8 inches for the main lines; and stoneware pipes from 18 inches to 9 inches in diameter for the collateral and branch sewers, with a maximum gradient of 1 in 11 and a minimum gradient of 1 in 300, the whole of which is ventilated at about every 100 yards, by means of 6-inch and 9-inch pipes from the crown of the sewer to the surface of the public roads, with cast-iron ventilating covers. A great many of our sewers are of very long lengths compared with the number of houses on the line of sewers, the majority of houses being detached, thus having a very small flow of water through them; the natural consequence was that smells did arise from the sewers and road ventilation at the upper ends.

In March 1878 I reported to the Sanitary Committee the defective state of the sewers, viz. the want of more ventilators, and that flushing tanks should be provided at the head of all the sewers, because of the long length of the sewers compared with the small number of houses as before stated, and I was instructed to put in more ventilation from time to time.

Later on, in consequence of so many complaints of the smell from the sewer ventilators in the roads at the higher parts of the town, I again reported upon the defective state of the sewers, for the want of a proper system of ventilation and flushing. At the same time I prepared a scheme to ventilate by means of open ventilators at the top ends of all the sewers and branches, with flushing tanks 12 feet long and 3 feet 6 inches diameter, constructed of brick and concrete, each to hold 600 gallons of water, and provided with one of Field's annular siphons made in stoneware by Messrs. Sharp, Jones & Co. (Bourne Valley Pottery, close to this town) the licensees are Messrs. Bowes, Scott & Read, of Broadway Chambers, Westminster. These siphons are tested at the manufacturers before leaving the works. The whole number we have fixed have acted in a most efficient manner, and quite up to my expectations. They discharge the 600 gallons of water in 1¼ minute after starting. Thirty-one of these tanks have been constructed, and, where possible, supplied with surface water, in addition to having a hydrant on to the water main within a few feet from each tank. We are extending the sewers in the new district, in which ten more of these automatic flushing tanks are being constructed.

The ventilation is carried out by means of open ventilation at the top ends, and where there is a change of size and gradient in the sewers, constructed of wrought-iron galvanised pipes 6 inches in diameter, carried up the sides of trees or houses which and where found most convenient, and wherever we could obtain permission. These ventilators vary in height from 9 to 60 feet from the surface of the ground. This work of obtaining permission has not been done, I can assure you, without considerable opposition from the residents near. There are sixty-one of the high ventilators fixed. We have had these ventilators fixed against the trees, painted a dirty green to make them as little objectionable in appearance as possible; those against the houses any colour the owners wished.

The road ventilators at the lower part of the town act as "*air inlets*," and the higher ones up the sides of trees and houses as "*air outlets*," thus keeping up a constant current of fresh air through the sewers from end to end, thereby keeping them sweet and free from foul smells; this is ventilating on the same principle as directed by the Local Government Board Model-Building Bye-laws for house drains. It is a great satisfaction for me to be able to state that since the scheme has been in operation we have had very few complaints of the smell from the road ventilators in the higher parts of the town, and in fact not anywhere where we have been able to complete the ventilation. The system is self-acting; but to make it perfectly successful, compulsory powers are required to enable local authorities to place them in the best position required.

Before my scheme of flushing and ventilation came into operation, there were constant complaints of the nuisance from the smell from the road ventilators in the higher parts of the town; the only means of flushing was by means of using a water-cart, which was a very inefficient and expensive operation for the purpose, besides having to resort to charcoal trays in the ventilators, which I look upon as nothing more or less than a plug to bottle up sewer air.

After my experience, I am very strongly of opinion that no system of sewers can be perfect without flushing and ventilation combined (*Hear, hear*); ventilation will not do without flushing, nor flushing without ventilation (*Hear, hear*). Since the Commissioners have extended the district they have obtained permission to borrow the money to sewer all the public highways at the public expense, and all the private roads are to be done under the 150th section, so that every road and street in the whole of the new district will have a public sewer, say within six months from this time.

Sanitary Hospital.

In the year 1877 a site of land, comprising 5 acres 1 rood 11 poles, was purchased for the purposes of digging gravel, and for the erection of a sanitary hospital for the Bournemouth Commissioners. The site is situate on the Shaftesbury estate, Bournemouth, and consists of a very dry gravel soil, the surface of which is about 130 feet above Ordnance datum. Of the above extent of land, 3 acres 1 rood 24 poles is set apart for the erection of the hospital and its surrounding grounds. The plans, sections, and elevations of the several buildings which have been erected, were prepared by myself as the surveyor to the Bournemouth Commissioners.

Description of Building.

The administrative department is constructed of brick, having hollow walls, with red and white brick facings.

On the ground floor there is accommodation for surgeon and matron, with kitchen, scullery, and stores, and on the first floor three bed-rooms, two store-rooms, and a bath-room. Each floor is 12 feet in height. All internal angles, both vertical and horizontal, are rounded and finished off with a face of Keene's cement, in order to prevent in the one case the stagnation of air which necessarily occurs in the corners of a room, and in the other, the accumulation of dust in the angles formed by the walls with the floor.

The wards provide accommodation for ten beds and two nurses, all situate on the ground floor, with hollow walls constructed of brick with red and white brick facings. The whole of the walls internally are finished off with a face of Keene's cement, and all internal angles both vertical and horizontal are rounded and finished off with a face of Keene's cement, the same as in the administrative department, which presents an excellent impervious surface and possesses the great advantage of being capable of thorough cleansing and disinfection in a few hours. The flooring throughout is constructed of 1¼-inch batten flooring, with iron tongues, and a good intervening space for the free circulation of air under.

The dimensions of the smaller wards are 18 feet by 18 feet, with a superficial area of 324 feet each ward, and a cubical space of 2187 feet for each patient. The dimensions of the larger wards are 18 feet by 30 feet, with a superficial area of 540 feet to each ward, and a cubical space of 2340 feet for each patient.

The window-sashes are an improvement on the ordinary double-hung sash windows, inasmuch as great care has been taken to avoid all recessed or projecting mouldings and square angles, in which dust and dirt are usually allowed to accumulate. The lower sash in each window, moreover, is specially designed so as to allow it to be raised sufficiently to admit of ventilation at the meeting bars without involving an opening at the sill.

In the upper part of these windows is a fanlight hung to a transom to fall inwards. Each ward-room is filled in with French casements opening down to the floor, in order to give access to a balcony, on to which the patients, while still in bed, may easily be wheeled whenever the weather permits. The glazing in all the windows is of stout sheet glass in two thicknesses, with an interspace of three-quarters of an inch, an arrangement which will tend to preserve uniformity of temperature in the interior.

Large ventilating apertures, fitted with Ellison's "radiator" ventilators, are provided in the external walls of the wards at the floor level, and Boyle's extraction ventilators in the ceiling of each ward. The gas brackets are fitted throughout with extraction pipes to convey away the products of combustion.

The material selected for facing the walls of the corridor and verandah is glazed brickwork.

On the outer side of the open corridor will be a projecting building containing water-closets and sinks, both of which will have efficient means of cross ventilation, also a place for a movable bath, for use in the wards, with taps for hot and cold water, and a proper sink for emptying it.

There will be a large wash-house, 22 feet by 13 feet, detached, and at a considerable distance from the wards, with two sinks, and a boiler with furnace under; also a disinfecting room divided into two parts and fitted up with one of Washington Lyon's disinfectors, a mortuary 13 feet by 11 feet, and an ambulance shed 13 feet by 10 feet. This building is constructed of brick, with red and white brick facings, and the whole of the internal walls and roof timbers are twice lime-whitened.

The drainage of the administrative department, wards, wash-house, &c., will be by means of a length of 9-inch sewer to a man-hole in the Christchurch Road, and from thence, by means of a 12-inch pipe sewer, connecting with the main sewer at the junction of the Ashley Road. The ventilation of the drains will be by means of eight ventilators placed about 100 yards apart, with proper air inlets and air outlets.

At the head of all branch drains is fixed one of Field's patent automatic flush tanks, five in number. The whole of the drains of water-closets, sinks, &c., are properly disconnected.

The estimated cost for carrying out the above works, including the fencing to enclose the grounds, is 3900*l.*

Roads.

We have a length of 39 miles of road; the level parts of the main roads are made with Mendip limestone from the Mendip Hills, and the hilly parts of the main roads are made with surface picked flints from near Blandford. Other roads are made with gravel dug from our pits. All the paving to the footpaths is done with tar-paving, the kerbing and channelling with Purbeck stone.

Pleasure Grounds.

The central pleasure grounds, running through the centre of the town, are a mile in length from the sea, taking a direction of north-west; the Bourne stream running through it, with its small bridges and cascades, makes it a very pretty feature. It has an area of 29 acres 3 roods.

On the eastward side of the stream is a large pine wood, which on account of its sheltered position is a very favourite resort of invalids when the weather is a little too rough or too cold for them on the cliff or in more exposed places. In the months of June and July the wood is usually very gay with rhododendrons, which grow wild under the trees, and which are to be seen here in greater perfection than in almost any other part of the country.

The Boscombe Chine Gardens.

In accordance with instructions received from the Bournemouth Commissioners, plans were prepared, and have been laid out by myself, with the aid of the Pleasure Grounds Committee, as public pleasure grounds. The extent of the ground laid out comprises 9 acres 39 poles. There is a broad path running through the centre of the grounds from the entrance in the Christchurch Road to the sea, 15 feet wide, with an easy gradient, so that invalids' carriages may pass through the grounds in the same manner as they do from the Square to the pier in the centre of the town.

The rustic character of the Chine has not been altered in any way.

The objectionable open water-course has been converted into a covered drain with 2-feet concrete pipes, and a number of catch-pits to collect the surface water.

Along its course has been formed a small ornamental lake, which is a feature in the gardens, and which in the summer serves for children sailing their boats.

In the centre of the grounds across the ravine or chine an oak rustic bridge has been erected.

On the east side of the carriage drive, on the table-land near the main road, there is a lawn-tennis ground, and round the boundaries of the grounds near this part are some of the most charming little sheltered walks to be found anywhere in or near Bournemouth.

The Spa has been restored, with a rustic shelter-house over it, which has for so many years past been the source of attraction to visitors.

The grounds are planted principally with fir trees and rhododendrons, and seats are placed in convenient spots about the grounds.

The whole of the grounds are surrounded by an unclimbable fence, with proper gates at each entrance.

The whole of the work has been carried out within the estimated cost, viz. 1651*l*.

Lighting.

There are at the present time 569 public lamps (including thirteen larger ones) in use. The ordinary lamps are supplied with gas, and paid for according to average meter indication, viz. with one meter to every tenth lamp; and the larger ones are paid for according to positive meter registration, viz. by a meter fixed in the base of each post; the lighting, cleaning, extinguishing, painting, and repairing are executed by our own men.

The indices of the meters are taken, and the account of gas consumed is made up monthly; and by this arrangement we are enabled to detect any defects, and remedy the same forthwith.

During the past year seventy new additional lamps have been provided, and fixed by us, five of which are of the larger kind, at a cost of 357*l.* 8*s.* 6*d.*, and paid for out of current expenditure.

During the year the lamps were lighted on 323 nights, being a total of 1646 hours; but during the period between June 3rd and August 8th, only seventy, including all the large lamps, were lighted for the purpose of lighting the main thoroughfare between the east and west railway stations.

The total quantity of gas consumed during the year was 4,466,260 cubic feet, costing 827*l.* 19*s.* 10*d.*, part of which was charged for at the rate of 4*s.* 6*d.* per 1000 cubic feet with 10 per cent. discount and part at 3*s.* 6*d.* per 1000 cubic feet net.

The lighting, extinguishing, and cleaning of the lamps, also the painting, repairs, maintenance, and alterations, have cost 503*l.* 7*s.* 2*d.*, making together a cost of 1331*l.* 7*s.* for the year. Taking 488 as representing the average number of lamps (assuming each large lamp to be equal to five ordinary lamps) burning for the twelve months, each lamp has cost 2*l.* 14*s.* 6¾*d.*

DISCUSSION.

Mr. C. Jones: As the Honorary Secretary of this Association, it has been my privilege to visit many places, but I do not know any place where I have experienced such thorough gratification, so far as the pleasing of the mind and the recreation of the body are concerned, as I have in Bournemouth. It is my first visit to Bournemouth, but if I keep in the same mind as now, it will not be the last by a great many. I have heard very much of Bournemouth, with its fir-trees, its splendid atmosphere, its magnificent sea views, and its walks. I have, as a neighbour, Mr. Thornhill Harrison, one of the most esteemed of the Government inspectors, and again and again has my attention been called by him to the way in which work has been done in Bournemouth, until I became almost a little envious, and determined that on the very first opportunity I would go and see this wonderful Bournemouth. When I meet Mr. Harrison next I will tell him that all he has said about Bournemouth is perfectly correct. Indeed, I might say the half has not been told me, because if you combine the beauty of the scenery with the high state of sanitary efficiency it would be difficult to put into language that which would convey to the mind of an expert all that one gained by a day's visit to Bournemouth. I know that so much depends upon the high sanitary efficiency of a town in the building of it up that I cannot help feeling that very much is due—I will not say to Mr. Andrews alone, because there were those who went before him, but to Mr. Creeke and Mr. Andrews, combined with a board of far-seeing men; for though I do not know the members of the board, I know the difference between a far-seeing local board and one that was composed of men who could only see as far as their noses. They must have a board at Bournemouth, not only up to the time, but going a step in front. I have the honour to represent an outlying suburb of London, which has grown up in twenty-two years, and is now perhaps the most important district on the west side of London. But proud as I am of it, I will go back from Bournemouth assured that there were some places looking up quite as much, and in quite as important a position as Ealing. The drainage of this town seems to have been carried out in a way that must commend itself to all of us. I commend the continual flushing of the sewers and the system of ventilation, and the multitude of ventilating pipes which we have seen. I am pleased to find that very much of the feeling against this mode of ventilation seemed to have disappeared if it ever existed at Bournemouth. It is very important that sewers should be thoroughly ventilated, and I know of no town where I have seen that more efficiently carried out than in Bournemouth. They have here the combination of ventilation and flushing which must go together, and which provided a perfect system. I am not aware of the death-rate of Bournemouth, but I would undertake to say it was very low. I congratulate Mr. Andrews upon the support which I am sure the Board of Commissioners accord him. I am sure they were one with him in every good work that was carried out, for if they were not they would not see such marks of progress. The Bournemouth Commissioners were doing their work well, and were making the town prosperous to a degree which must be exceeding their most sanguine expectations. Mr. Jones next referred to the excellence of the hospital, and concluded by congratulating Bournemouth upon the position it occupied, and said he looked forward to the carrying out of those works now projected, to raise the town still higher in public estimation than it was at present.

Mr. Newman: I understand the tall shafts were erected at the higher parts of the districts. My own observations have led me to the conclusion that the current of air was generally with the sewage, and not against it.

Mr. Pritchard: The day has been one of great interest, enjoyment, and instruction. Mr. Andrews' paper has been very ably prepared and explicit. I regret to say there is nothing I can find fault with. You have heard from Mr. Jones an opinion which every one here must endorse, that the system of ventilation and flushing—two most important points in the working of sewers—appeared to be, he would not say perfect, but superior to anything we have before inspected. I agree with Mr. Jones, that ventilation and flushing are absolutely necessary, but something further is needed—that is that the sewer itself should be properly constructed. In Bournemouth they appeared to be in the fortunate position of having sewers well constructed, properly ventilated, and efficiently flushed. I wish to ask Mr. Andrews whether any difficulty is experienced in removing entirely from the beach the objectionable matters which are so easily and efficiently got rid of from the sewers into the waters of the beach? Was any portion of the objectionable matter thrown back upon the beach? Mr. Andrews said in his paper that there were not many complaints of offensive smells in connection with the sewers. I would be quite prepared to give evidence on that point; for the manhole covers had been taken off, and if there had been anything objectionable, the scientific noses of this Association would have detected it. You would agree with me that the down-cast and up-cast shaft was the proper principle of ventilation. That is adopted, and in addition Mr. Andrews gave the additional precaution of a trap. Referring to Mr. Newman's question, as there was a downward flow of water, there was in an inverse ratio an upward flow of air.

Mr. Godfrey: In reference to the difficulty experienced in getting permission to put up ventilators, I think local authorities should have full power to carry their sewers to their natural termination. I would suggest that the Council should consider the appointment of a Parliamentary Committee, who should consider matters affecting the Association, especially now that a local government measure was foreshadowed by Conservatives and Radicals alike.

The District Secretary said he would bring the matter before the Council.

Dr. Nunn (Medical Officer of Health), in the course of some remarks, spoke of the friendly spirit in which the Surveyor and himself worked together, and said he hoped other towns had as competent surveyors, men as keen about the sanitary perfection of their districts as Mr. Andrews. The system of flushing was entirely worked out by Mr. Andrews, and it certainly had effected a great sanitary improvement in the district. Referring to the death-rate of Bournemouth, Dr. Nunn pointed out that it was one of the great sanatoriums of England, where people in the worst stages of consumption came—too often only to die—and half the deaths, certainly the half in winter, were those of visitors. The death-rate of Bournemouth, including visitors, was not more than 16 or 17 per thousand. He believed he was right in estimating the deaths of the inhabitants of the town at 10 per thousand. That was almost the ideal death-rate which Dr. Richardson had spoken of in his paper on "Salute Land." The Board of Commissioners had adopted the principle of *sanitas sanitatum, omnia sanitas.* Dr. Nunn then alluded to the elaborate arrangements which were made for disinfecting, and in referring to the Sanitary Hospital, said he considered it to be the most perfect hospital in England. It was perfect in construction, and everything of the best kind was provided. They had also one of Lyon's patent disinfecting machines, and they would be able to disinfect every article of clothing and bedding brought there.

Mr. Andrews made a brief reply; and in alluding to Mr. Pritchard's question said that formerly some of the objectionable matter was thrown back to the beach, but since the central outfall had been extended 600 feet further this had been remedied.

The Members walked through the Pleasure Gardens to the Station, where a special train was in waiting to convey them to Messrs. Sharp, Jones and Company's pottery works at Bourne Valley. After luncheon, provided by Mr. Sharp, the pottery was inspected. The treatment of the new clay and its prompt *transformation into socket pipes was witnessed. A variety of mould work, chiefly appertaining to drainage, was also inspected. The automatic discharge of a large tank by a stoneware annular syphon (Field's patent) at the rate of* 450 *gallons per minute, the power recommended for flushing a* 9-*inch sewer, was also inspected, with many other interesting features. The Members then returned to Bournemouth, where the arrangements for the flushing and ventilation of the sewers were examined. Then they proceeded in two brakes to the Sanitary Hospital, with the whole of which they expressed admiration. Boscombe Gardens were visited, and the Members then returned to the Town Hall, where they inspected some plans of the district, of the hospital, of the outfalls, and of the automatic flushing arrangements. In the evening the Members dined together at the Criterion Hotel.*

DISTRICT MEETING AT STRATFORD UPON-AVON.

November 14th, 1885.

Held at the Town Hall, Stratford-upon-Avon.

Mr. R. Vawser, *President, in the Chair.*

Besides the Members of the Association, Sir Robert Rawlinson, C.B., the Mayor of Stratford, Mr. Arthur Hodgson, C.M.G., and several visitors were present. The Mayor of Stratford, on behalf of himself and the Corporation, cordially welcomed the Association to the borough. Mr. E. Pritchard was unanimously re-elected Honorary Secretary for the Midland District.

STRATFORD-UPON-AVON WATER SUPPLY.

By J. EDWARD WILLCOX, Assoc. M. Inst. C.E.

The question of a water supply for the town of Stratford-upon-Avon is one which has for some time past engaged the attention of the local authority, so that it may perhaps be well to preface this paper with a few remarks as to the existing supply and also to briefly enumerate the events which led to the adoption of the scheme which is now being carried out.

The borough of Stratford-upon-Avon has an area of 3865 acres, a population, according to the census of 1881, of 8053, showing an increase of 831 during the last decade, the present population being 8400: the rateable value is 31,710*l*. The present supply of water for domestic purposes is wholly obtained from wells, the majority of which are shallow and sunk in the gravel beds overlying the red marls of new red sandstone formation on which the town is situated; but in the higher portion of the town towards

Clopton the wells are deeper. Complaints have from time to time been made regarding the water from the wells, both as to its excessive hardness and also its impurity: the latter is not surprising, bearing in mind the gravelly substratum and in many instances the close proximity of the drains to the wells, the supply from which in not a few cases has been condemned.

In addition to the supply from the wells, there is, for the purpose of street watering and the flushing of sewers, a 6-inch main laid through a few of the principal streets, which is fed by the Birmingham and Stratford Canal, the sum of 70*l.* per annum being paid for the accommodation. Although the question of a water supply had been mooted for some time previously, the first definite step taken in the matter was in 1881: in this year a company was formed and application to Parliament was made for power to supply not only Stratford-upon-Avon but also Bearley, Wotton Bassett, and several surrounding villages with water. This brought the matter prominently before the Town Council (acting as the Urban Sanitary Authority), who after some opposition decided that so important a sanitary measure (apart altogether from its value as a financial undertaking) should be under their sole control and not in the hands of a private company. It was therefore determined to oppose the Bill in Parliament; but before the stage of active opposition had been reached, a compromise was effected, and the company, receiving a sum of money in payment of their initial expenses, agreed to abandon the Bill. As at this time the Town Council were contemplating an expenditure in connection with the disposal of sewage, and Mr. E. Pritchard, M. Inst. C.E., of Westminster and Birmingham, having been called in to advise on that matter, he was also instructed to report on the question of water supply, it being considered advantageous that the two schemes should go hand in hand.

After a series of most careful investigations, Mr. Pritchard reported in favour of obtaining a supply from Snitterfield, and his report having been adopted, an application was made to the Local Government Board to sanction the borrowing of 23,000*l.* for the water and sewerage works, which loan was granted after an inquiry had been held. Tenders were immediately advertised for, and the present works commenced.

The Snitterfield scheme is one for the supply of water by gravitation, upon the principle of constant service at high pressure, the water being abstracted from the Snitterfield Brook and conveyed by means of an underground conduit to a reservoir about three-quarters of a mile distant from the point of abstraction; from thence, after being filtered, the water passes to the supply mains. The supply from the brook is augmented by means of water from perforated pipe adits, which is conveyed direct to the filter beds and supply mains as described further on. The drainage area contributing to the Snitterfield Brook at the point of abstraction is 700 acres, the average annual rainfall being about 27 inches, so that there falls upon this area a volume of water equal to 428,793,750 gallons per annum; and of this quantity it is found that in 1883 only 20 per cent. of the rainfall was gauged as passing over the weir at the proposed point of abstraction, thus giving an average quantity of 85,758,750 gallons from this area; the gaugings for 1884 showing a less percentage than the previous year.

The supply to the town is proposed at 15 gallons per twenty-four hours per head of the population, assuming water waste prevention fittings will be adopted; provision being made for a population of 10,000, this would give a requirement daily of 150,000 gallons, or 54,750,000 gallons per annum: if we take the two results we get the annual yield of the Snitterfield Brook as 85,758,750 gallons and the supply required for the town 54,750,000 gallons, or an excess of 31,008,750 gallons running to waste for the year referred to. It should here be stated that no compensation water has had to be provided for. In addition to this source of supply, a considerable quantity of water has been met with in the gravel drift overlying the new red marl, and which was passed through in excavating for the conduit; this water will also be available for the supply of the town. The quantity obtainable from this source cannot be estimated until the completion of the conduit and pipe adits; there is, however, every reason to believe that these gravel beds will yield a large volume of water, as during the construction of the conduit it has been found necessary to pump both night and day.

Of the water from the Snitterfield Brook, Dr. Bostock Hill, the county analyst, reports as follows:—"The analytical results which I enclose show it to be a water in every way well adapted for a town supply, except that at the present time it exhibits evidence of contamination with fresh organic matter.

"There is no nitrogen as nitrate present, the chlorine is very small in quantity, and the hardness not particularly large; in appearance it was turbid, but this is accounted for by the fact that the stream was in flood at the time, and receiving therefore a large amount of surface water and impurity. Looking at these facts, I am of opinion that, after proper collection, storage and filtration, the water would be well suited for the requirements of a town supply."

The following is a copy of Dr. Hill's analysis:—

ANALYSIS EXPRESSED IN PARTS PER 100,000.

	Total Solid Impurity.	Organic Carbon.	Organic Nitrogen.	Ammonia.	Nitrogen as Nitrates.	Total combined Nitrogen.	Previous Sewage Contamination.	Chlorine.	Albuminoid Ammonia.	Hardness.		TOTAL.
										Temporary.	Permanent.	
Snitterfield Brook	33·0	Large		·002	—	—	—	1·0	·014	10·74	12·86	23·6
Water from Adits	34·0	—	—	·024	—	—	—	1·3	·014	15·90	13·14	29·04

Brick Conduit and Perforated Pipe Adits.

The conduit which conveys the water from the Snitterfield Brook to the reservoir is 1080 yards in length, of which 700 yards was constructed in tunnel at depths below the surface from 20 to 65 feet, the headings being driven for a portion of the distance in hard rocky marl, which necessitated blasting operations being carried on. Very considerable difficulty was experienced during the progress of this work, owing to the running sand which overlies the marls here twice bursting into the heading and completely filling portions of them: the geological section of the first 200 yards of the tunnel is of great interest, as besides the green, red, and mottled marls, black shales abounding in fossils (Rhætic beds) were passed through. The conduit is circular in section, being 2 feet 6 inches in diameter, and constructed with 9-inch brickwork in cement, the invert being formed with brick invert blocks properly radiated: it has a fall of 1 in 1610. Beneath the conduit, and to the one side, is the perforated pipe adit, which is surrounded with clean assorted gravel as a filter medium, and collects the water obtained from the gravel beds; these adit pipes are 12 inches in diameter, with sockets, and are laid open-jointed; they were specially manufactured by Messrs. Doulton & Co., the perforations being on the top portion of the pipe only, and ½ inch in diameter.

Manholes are provided for the inspection of the culvert. The arrangements at the point of the abstraction of the water from brook present one or two features of interest. Means are taken to divert the water into a chamber which is in direct communication with the conduit and also with the pipe adit for the purpose of flushing them if necessary; this chamber is about 12 feet deep, and is provided with an overflow which is practically the overflow for the reservoir, its level being identical with the top water of the reservoir. As will be seen, the quantity of water in reservoir can to some extent be regulated from this point, the water in chamber being an indication of the quantity in the reservoir. A house for the caretaker has been built adjoining the intake.

Reservoir.

The reservoir is situated in a valley near to the King's Lane, on a portion of what is known as Hollow Meadow Farm, about 3 miles from Stratford-on-Avon, and it occupies a total area of 7 acres 3 roods 4 perches. The site is admirably adapted for the purpose, owing both to the superficial configuration of the ground and to the fact that the substratum is a bed of retentive marl. The top water area of the reservoir is 4½ acres, the average depth being 18 feet 6 inches, and its storage capacity is 19,200,000 gallons, or after deducting evaporation, 116 days' supply at 150,000 per day, supposing all flow of water into reservoir to have ceased; but as the minimum flow from the brook or from the pipe adits will be always available, this period would be much increased. The bottom of the reservoir is sloped from the sides towards the centre and towards the outlet, the depth of water at the top end being 14 feet 6 inches, at the bottom end 24 feet 6 inches.

The excavation from the bottom went in a great measure to form the embankment, which on plan is a segment of a circle having a radius of 100 yards; it is 212 yards in length, and is constructed with an inside slope of 3 to 1 and an outside slope of 2 to 1, with a roadway formed at the top. All the inside slopes of the reservoir are protected by 6 inches of concrete to top water level, and above that turfed, as is also the outer slope of the embankment.

The natural formation of the ground renders the water-tightness of the reservoir comparatively easy to secure, and it was not found necessary to go lower than 10 feet at the deepest point to secure a good foundation for the puddle wall, which is 6 feet wide at the bottom and 3 feet wide at the top, and is carried 2 feet above top water level. An abundant quantity of good material for the puddle was found on the ground, which before being used was properly weathered and then passed through a pug mill.

The top water level of the reservoir is 292·50 above Ordnance datum, the top level of bank being 297, the water level being 165 feet above surface level of ground in front of the town-hall, and 122 feet above the highest portion of the town supplied. The water for the supply of the town is drawn from the reservoir by means of a cast-iron standpost 24 inches diameter and 27 feet 6 inches high, with two 9-inch reservoir sluice valves at levels 9 feet 6 inches and 18 feet 6 inches respectively above the bottom, and there is also an 18-inch valve and an 18-inch outlet at bottom. A wrought-iron lattice-girder gangway, 74 feet 3 inches long, supported in centre by cast-iron columns, leads out to the standpost, and from the end of this gangway the valves are manipulated.

The 18-inch outlet consisting of cast-iron socketed pipes is taken beneath the centre of the embankment upon a solid foundation of hard marl, each pipe being jointed with yarn and lead, and supported on blocks of concrete, which also form stop blocks to prevent the creep of the water; a cast-iron diaphragm was for the same reason placed on either side of the puddle trench where the outlet crossed it; the space between the concrete blocks was filled in with puddle. At the inner toe of the embankment by the outlet are wing walls of 18-inch brickwork in cement.

Filter Beds.

The filter beds are two in number, and fed by an arrangement of piping which leads the water from the reservoir or from the adit pipes, the latter being brought round the outside of the reservoir by 12-inch iron pipes. Each filter bed is 65 feet by 30 feet internal measurement, the walls being partly of concrete and topped with brickwork; each has an area of 217 superficial yards, and is capable of filtering 151,900 gallons per twenty-four hours. The filtering material is 5 feet 6 inches in depth, and consists of five layers of gravel of sizes approaching hens' eggs, walnuts, beans, peas, and shot; the whole is finished with a bed of 2 feet of sand.

The water is drawn off the filters by an arrangement of perforated earthenware pipes, and taken direct to the pure-water tank, and from thence to the supply mains: one of Glenfield & Co.'s sand washers is placed in the centre of each filter bed; it consists of an iron tank having a false bottom of perforated iron plates: to wash foul sand all the pressure needed is just sufficient to keep the sand from lying on these plates, the waste water being carried off by an overflow pipe.

Distribution.

The water is conveyed to the town by means of a 7-inch main which is capable of discharging 555,800 gallons daily, and it is then distributed by pipes of 6 inches, 4 inches, and 3 inches diameter; these pipes were subjected to tests as follows: the 7-inch and 6-inch to a pressure of 400 feet head, the 4-inch to a pressure of 500 feet head, and the 3-inch to a pressure of 600 feet head, the pressure being maintained for three minutes: the total length of pipes laid is rather over 11 miles. It should here be mentioned that the 6-inch pipes already laid for the purpose of street watering &c., were utilised, which will explain why pipes of that size are used in streets where smaller ones would have been amply large. All pipes are socket and spigot pipes, the joints being made in the usual manner: the interconnection of the mains has been carefully considered with a view to constant circulation; there are in consequence but few dead ends. Sluice valves and air valves are placed where required, and eighty-eight of Bateman and Moore's patent ball hydrants are provided, being a proportion of one hydrant to every 160 yards of main laid in the town: in fixing the position of these hydrants the character of the buildings to be protected was considered. Final arrangements as to house services have not yet been made.

Cost.

The entire cost of these works, including purchase of land, legal and engineering expenses, is estimated at about 21,000*l.* The contract for the supply of iron pipes and special castings was let to Messrs. C. E. Firmstone Bros., Lays Foundry, Stourbridge, the amount of their tender being 3063*l.* For the second contract, which embraced the construction of reservoir, brick conduit, laying supply mains, and all other work, the tender of Mr. George Law, of Kidderminster, was accepted, the amount being 14,077*l*. The standpost, gangway, and other special castings, as well as valves, hydrants, &c., were supplied by the Glenfield Company, Kilmarnock.

The works were commenced November 1884, a period of eighteen months being allowed for their execution, and it is anticipated that they will be completed well within the stipulated time.

The scheme was designed by Mr. E. Pritchard, M. Inst. C.E., of Westminster and Birmingham, the author acting as resident engineer.

STRATFORD-ON-AVON SEWERAGE AND SEWAGE DISPOSAL.

By ALFRED T. DAVIS, Assoc. M. Inst. C.E., Borough Surveyor.

Matters relating to sewerage and sewage disposal have been so often discussed by the Association that it is somewhat difficult for one to write anything fresh on these subjects, still it may not be uninteresting to some, at least, of the Members present to learn what has been done to improve the sanitary condition of this historic old town.

We have it on the authority of Mr. J. O. Halliwell Phillipps, that about the year 1551, "and for many generations afterwards, the sanitary condition of the thoroughfares of Stratford-on-Avon was, to our present notions, simply terrible. Under-surface drainage of every kind was then an unknown art in the district. There was a far greater extent of moisture in the land than would now be thought possible, and streamlets of a water-power sufficient for the operations of corn-mills meandered through the town. This general humidity intensified the evils arising from the want of scavengers, or other effective appliances for the preservation of cleanliness. House-slops were recklessly thrown into ill-kept channels that lined the sides of unmetalled roads; pigs and geese too often revelled in the puddles and ruts; while here and there small middens were ever in the course of accumulation, the receptacles of offal and every species of nastiness. A regulation for the removal of these collections to certain specified localities interspersed through the borough, and known as common dunghills, appears to have been the extent of the interference that the authorities ventured or cared to exercise in such matters. Sometimes, when the nuisance was thought to be sufficiently flagrant, they made a raid on those inhabitants who had suffered their refuse to accumulate largely in the highways. On one of these occasions, in April 1552, John Shakespeare was fined the sum of twelve-pence for having amassed what was no doubt a conspicuous *sterquinarium* before his house in

Henley Street, and under these unsavoury circumstances does the history of the poet's father commence in the records of England."

The town now enjoys the reputation of being a very clean and well-kept one.

The area of the borough is 3865 acres, the population computed to date is 8400, the rateable value is 31,710*l.*, and the death-rate during the past quarter equivalent to an annual rate of 14·8 per 1000.

Sewers.

The sewers were designed and constructed exactly thirty years ago by Mr. Alderman E. Gibbs, who was then the engineer and surveyor of the old Board of Health, and up till a few months since they discharged their contents, in a crude state, into the river Avon. The system is that known as the combined system. The pipe sewers vary in diameter from 9 to 18 inches, and the brick sewers from 3 feet by 2 feet 3 inches, to 4 feet 6 inches by 3 feet. There are several side-entrance manholes to the main sewer, but there are no manholes to the pipe sewers, the straight line and gradient system, with manhole or lamphole at each change of line or gradient, evidently, not being then in vogue. From an inspection of the plans, nearly the whole of the sewers appear to have good gradients, and those which have been opened up by the author for the purpose of making a connection, or otherwise, have generally been found tolerably free from deposit, and very well constructed.

Drains.

The greater portion of the house drains are in direct communication with the sewers, and in many instances which have come under the author's notice, they have been found to have uneven gradients, the street portion frequently having a precipitate fall at the expense of the house portion. These latter have generally been found to contain deposits of ashes and other matter in a decomposed state, it having been the custom to allow ashpits and middens to be drained into the sewers, a practice which cannot be too strongly condemned.

The construction of the majority of the drains may have received proper supervision in the first instance, but the Members of the Association are only too well aware that after a drain has been inspected and approved, alterations are frequently made by different men possessing ideas of their own, so that what may have been a very good arrangement in the first instance is ultimately converted into a very bad one.

Only a few days ago the following case came under the author's notice. The waste-pipe from a bath in one of the principal establishments of the town was found to be in direct communication with the drain, which, in turn, was directly connected with the public sewer, and as the waste-pipe was entirely untrapped and the drain unventilated, this pipe was, to a certain extent, doing service as a ventilator and conveying not only drain-air but sewer-air into the bath-room ; there were also other serious defects in the connection, but it is unnecessary to enumerate them.

Middens.

The author is sorry to say that many of those abominations commonly called middens still exist in the borough, but he is pleased to say that they are being removed one by one, and he hopes to see them entirely abolished as soon as the waterworks are completed, and the use of the water-closets fully appreciated.

Flushing.

The sewers are flushed by means of a portable tank holding 1000 gallons. This tank is made of galvanised iron $\frac{1}{8}$ of an inch thick, riveted to a strong angle-iron frame, and mounted on four wrought-iron wheels, 6 inches on face, with springs. The water is discharged through a valve 9 inches in diameter with a leather sleeve; this sleeve is inserted into any one of the ventilation shafts, and the water contained in the tank suddenly discharged into the sewer to be flushed. The quantity of water used is regulated to suit the state of the weather and the amount of rainfall, but it is seldom less than 20,000, and sometimes exceeds 40,000 gallons per week. At the present time the water for flushing, as well as that used for the streets, is obtained from the Stratford and Birmingham Canal, which, previous to the laying of the new mains in connection with the waterworks now in course of construction, was conveyed to certain points in the town through 6-inch cast-iron pipes ; these pipes are now connected with the new mains, and the canal water is at the present time, and will be, until the new supply has been turned on, in circulation throughout the greater portion of the system. A sum of 70*l.* per annum is paid to the canal company for this water. It may also be mentioned that the above arrangement gives the town a certain amount of protection in case of fire.

When the waterworks are completed, it is the intention of the author to recommend the construction of automatic flushing-tanks at the upper ends of the sewers.

The order of flushing commences at the lower portions of the system, the higher portions or dead-ends being flushed last of all.

Ventilation.

The sewers are principally ventilated by means of 9 and 6-inch earthenware pipes carried up from the crown of the sewers and surmounted with cast-iron ventilating covers flush with the surface of the roads; these are placed at an average distance of 65 yards apart. Complaints have been pretty freely made from time to time concerning offensive smells from the ventilators, and in some instances cast-iron shafts have been carried up the sides of houses and buildings, the offensive surface ventilators being then closed. At the present time there are twenty-six of these shafts, the greater portion being only 5 inches in diameter; those recently erected, however, are 6 inches in diameter. Unfortunately complaints are still made, and certainly not without foundation, that some of the surface gratings do, occasionally, give off very offensive odours. Such being the case, it will naturally be thought by the Members of the Association that something must be wrong with the system, and, in the author's opinion, something is wrong, and it remains to be determined whence the evil arises. The sewers appear to have been well designed, and, as far as can be ascertained, they also appear to have been well constructed. The house connections, then, must be the cause of the emanations; they are untrapped, and owing to faulty construction in some instances, and to the want of flushing in others, they are slowly discharging decomposed matter into the sewers, and, as most of the drains are inadequately ventilated, and even in some instances not ventilated at all, the gases generated therein find an escape through the sewer ventilators.

It is the prevailing opinion in the borough that the sewer ventilator nuisance will be obviated as soon as the public water supply is fully laid on so that the private drains may be more effectively

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flushed. Such, of course, will be the case to a large extent, but it is extremely doubtful whether some of the partially choked drains, particularly those in connection with ashpits and middens, will ever be thoroughly cleansed by such means.

Sewage Disposal.

The disposal of the sewage of towns is still recognised as one of the great sanitary problems of the day; even the metropolis is greatly perplexed with the question. Stratford-on-Avon, therefore, in having provided itself with a means of disposal, may be congratulated on having so far got out of the difficulty. After being threatened time after time with injunctions to restrain them from polluting the river, the Town Council, in 1880, determined to take action, and, after carefully considering various reports and schemes from my predecessor, Mr. J. B. Denton, and others, Mr. Pritchard, in 1882, was called in to report upon the several schemes submitted, and was ultimately instructed to carry out a scheme of his own. This has just been completed, and the following is a brief description of it.

The scheme is a combined irrigation and filtration one, and the land, which was purchased from the late Marquis of Hertford, is 20 acres in extent and particularly suitable for the purification of sewage, the soil being of a light loamy nature, varying in depth from 18 to 24 inches, overlying a deep bed of gravel and sand. Three-fourths of this land (15 acres) have been laid out for surface irrigation, and the remaining fourth (5 acres) has been divided into eight beds for intermittent filtration. Pumping has had to be resorted to, as a portion of the town is situated at such a level that suitable land in the neighbourhood could not be obtained for a gravitation scheme.

The dry weather flow of sewage is about 162,000 gallons in twenty-four hours, which is after the rate of $20\frac{1}{4}$ gallons per head per day calculated on a contributing population of 8000. A rainfall of ·22 of an inch in twenty-four hours increases the volume to 238,000 gallons. Provision, however, has been made for a prospective population of 10,000, at the rate of 40 gallons per head, with the addition of 100 per cent. of rainfall, making a maximum quantity to be dealt with in the future of 800,000 gallons in twenty-four hours.

The sewage is intercepted at a point on the outfall sewer

470 yards from its outlet at the river and conveyed to the pumping station through a brick sewer 3 feet in diameter, which discharges into the pumping well after passing through a straining chamber; it is then pumped up to a chamber situated on the highest part of the farm, through a 9-inch cast-iron delivery main 425 feet in length, the vertical lift being 25 feet; it is conveyed thence by gravitation through 12-inch, 9-inch, and 6-inch earthenware deep socketed pipe-carriers throughout the length of the farm, and distributed thereon by means of distributing chambers 2 feet square; these chambers are fitted with cast-iron disc and flap valves, the former being particularly effective in their work. The land is drained with 15-inch, 12-inch, 6-inch, and 4-inch earthenware socketed pipes of second quality, varying in depth from 5 to 9 feet, and covered with assorted gravel for a depth of 18 inches, upon which is laid 6 inches of puddled clay to prevent the sewage, in an unpurified state, from passing direct into the drains. The sewage effluent passes through an effluent chamber situated at the western extremity of the farm, and from thence into the river by means of an 18-inch brick drain laid through the intervening meadows; one of these, known by the name of Chambers' meadow, 14 acres in extent, belongs to the Town Council, and a 9-inch carrier has been laid thereto and distributing chambers have been constructed, for the purpose of distributing sewage upon it when considered desirable. It is expected that this meadow will make a very good auxiliary to the sewage farm by giving it a greater season of rest than would otherwise be the case.

Pumping Station—Engines.

There are three 6-horse-power gas engines of the Otto type, fitted with self-starting gear; this, however, does not appear to be necessary, as the engine-man prefers to start them, and can do so easily, from the fly-wheels.

As most of the Members of the Association are familiar with this type of engine, it is quite unnecessary to describe it in detail. It may be well, however, to mention the following points. The exhaust silencers are fixed in a brick chamber outside the engine-house and covered with coarse gravel which materially deadens the sound. The water-tanks and gas-meters are placed in a separate room adjoining the engine-house, which helps to give the latter a neat appearance. The Town Council manufacture their own gas, and the price charged by the gas department is 3*s.* per 1000 feet, less a discount of 10 per cent. Of course sufficient time has not elapsed since the starting of the engines to allow of any reliable information being given as to the working expenses, &c.

Pumping Machinery.

The pumping machinery, which is situated inside the engine-room, consists of three double-acting pumps, patented last February by the makers, Messrs. Ball and Horton of this town. The cylinders are 10 inches in diameter and the stroke of the piston is 18 inches. The pumps are driven by means of leather belting from broad pulleys on the engines direct to a counter-shaft, on which are placed fast and loose pulleys having lever arrangements for sliding on and off the driving belts. The counter-shaft imparts motion to the pumps by means of spur-gearing, the pinions having lever arrangements for throwing them in and out of gear. These levers, together with the levers for sliding on and off the driving belts, are all concentrated at one point and can be readily manipulated. Each pump is capable of lifting 350 gallons of sewage per minute 25 feet high, and the arrangements are such that each engine may work any one or more of the pumps, or the three engines may be employed to work the whole. The pumping well is situated immediately outside the engine-house, which has the desirable effect of freeing, to a considerable extent, the engine-house from sewage odours. A pair of sludge agitators is fixed in the well, but these are not often required.

The pumps will be much better understood from the drawings, but the principal features are as follows :—The valves consist of rectangular metal flaps with indiarubber facings, which are set at an angle of about 45°, and it is claimed by the patentees that all solid or foreign substances lodging within the valve openings, or between the valves and their seats, are dislodged on the valves again lifting, or on the return movement of the piston. The pistons or buckets are composed of indiarubber gripped between two metal plates with an intermediate packing of hard wood, consisting of segments placed endways to the grain, to prevent any metal from coming in direct contact with the cylinders. These cylinders are lined with solid-drawn hard copper ⅛ of an inch thick. At the side of the pump casing or jacket, and directly opposite each valve, are fixed small hand or sight lids for the purpose of examining or gaining access to the valves or passages without having to take off the larger covers. These small lids are opened or closed in a few seconds by means of a vice handle and screw set-pin, working through a cross or catch bar, and they answer their purpose exceedingly well.

Cost.

Although the works are practically finished, they are not quite out of the contractors' hands, and therefore their exact cost cannot be given; approximately, however, it is as follows:—

	£	s.	d.
Cost of land, compensation to tenant, and law charges	4502	14	0
Engine-house and chambers adjoining	871	9	0
Engines and pumping machinery	1200	17	0
Intercepting outfall sewer	890	14	0
Cast-iron pumping main	62	18	0
Irrigation grounds, including Chambers' meadow and occupation road	1618	12	0
Filtration beds	781	5	0
General charges	183	0	0
Total cost ..	£10,111	9	0

The outfall works were designed and carried out by Mr. E. Pritchard, M. Inst. C.E., with Mr. J. E. Willcox, A.M.I.C.E., as resident engineer. The contractor for the general work is Mr. Geo. Law, of Kidderminster, and for the engines and pumping machinery Messrs. Ball and Horton, engineers of this town.

DISCUSSION.

Sir Robert Rawlinson: I should like to make a few remarks on the papers read, which I hope will have a practical bearing. I have listened with great pleasure to the papers, and in the one with regard to sewer ventilation, there is the remark that the open ventilators on the street-surfaces are very offensive. This complaint is not restricted to Stratford-on-Avon, but is common to all places where an old town has indulged itself for generations with cesspools. When you sewer such a town, the corrupt contents of these cesspools are discharged into the sewers, and one gallon of such corrupt matter would be much more tainted and offensive than 100 gallons of ordinary sewage from a well-drained town. You must not, therefore, conclude that your sewers are badly formed or badly ventilated, because, in their wilfully polluted state, you are suffering from that temporary nuisance which will abate most unquestionably when houses have been properly drained and cesspools have been abolished. I think my friend Mr. White will tell you he has found this to be the case in Oxford; that the ventilation of the sewers was protested against, but that it was really due to the horrible matter sent in from the cesspools, which caused the nuisance. All old sewers in old towns have become corrupt, and some may be practically choked; so that the sooner the inhabitants of Stratford-on-Avon, when they have got proper sewers, can get rid of their cesspools and old drains, the better. I heard nothing about subsoil water. I hope sincerely that there is some subsoil water in the sewers. Sometimes persons who have no practical knowledge of drains want you to keep out all subsoil water. I am no such advocate, as a dry sewer, laid upon a dry subsoil, is a most difficult thing to keep in order. I should very much prefer it with as much water in the sewer as would equal 3 inches on the invert, even if I had to contend with it at the outfall where I had to clarify the sewage. Then, with regard to the water supply, there is one caution I would give. The reservoir is comparatively small for the work it will have to do; and I would caution the person who has the management of it, that because he has the reservoir full during wet seasons, not to be extravagant with a use of water, but at all times to cultivate economy, or in a dry season the store of water may fail; as I have known a case where a reservoir was lowered at the beginning of a dry period, where there was only a limited gathering ground; and in one particular instance no rain fell upon that area (in this country of England) for twenty months continuous. This reservoir at Stratford will therefore require careful management. But extravagance in water, like all other forms of extravagance, should not be tolerated, as under good supervision and with proper waste-prevention fittings, 10 or 15 gallons per head is the best supply a house can have. It needs no more, and ought to have no more; and whoever may have the management of the waterworks in the future, should take care to pay sufficient attention to maintain the fittings in proper order in perpetuity. As well might one expect that a watch will go correctly, keeping proper time, if it is roughly handled, badly regulated, and otherwise neglected. Perfection of workmanship goes for nothing if proper care is not paid to it, and perfection of workmanship in sanitary matters will not go for one-tenth of what it ought, if there is not subsequent care. I am very sorry to hear there are foul middens still in Stratford-on-Avon, and that there are uncleansed places. There is one thing that I wish to say to the governing people of Stratford-on-Avon, and that is, that the foundation of all sanitary science is scavenging; and if I were asked what is the most important feature in sanitary science, I would repeat again scavenging. Your sewers, your drains, and water supply are all secondary considerations if scavenging is neglected. There should be no private vested interest in effete matter, as it should be removed by public scavengers from the premises of every individual, every manufactory, and every other place at the cost of the general body, and the cost should be paid out of the general district rate. I say that most earnestly, and I say it most advisedly. This is being contended against by some local boards, the members of which say they do not see why they should cleanse private establishments. But I know why this should be done. It is because if you leave it to private individuals it becomes the source of serious evil. And I say, as a last word to the people of Stratford-on-Avon, mature your scavenging arrangements and make them perfect. Do not let the work to any contractor; he will scavenge your town and take your fees in dry weather, but he will neglect the work in wet weather, because his contract does not cover exceptional or excessively wet seasons. The most economical way is for the Corporation or local board to do the work themselves, under their own management.

Mr. Cartwright: With regard to the size of the outfall sewer, in the paper on "Sewage Disposal" and under the head "Sewers," the dimensions were given as 4 feet 6 inches by 3 feet, but it was not stated what the area was which the sewer was intended to drain; mention was made that there was provision for the discharge of about half an inch of rainfall in the twenty-four hours: as this appears to me to be a low estimate for rainfall, and no provision for storm overflows, I wish Mr. Pritchard to tell us the extent of area the sewer is calculated to drain, and whether in designing it he made any allowance for the future extension of the borough. Under the head "Ventilation" it was said that the method carried out was that of open gratings to the surface of the street: this is a subject upon which Members of this Association have differed and will probably continue to differ; but after the remarks of our respected engineer-in-chief, I take it I shall not be wrong in concluding that we have his approval of this method; it is the one I have pursued for years past, and when any complaint is made of slight smells, instead of removing the grating, I put down an additional one. Passing now to the paper on "Water Supply," it occurred to me during the inspection, having regard to the extent of the watershed, as also to the future requirements of the district, that the capacity of the reservoir was small. My opinion has been somewhat modified during the reading of the paper by learning that the rainfall was comparatively small, and that no compensation water was required to be given out. Still, as Sir Robert Rawlinson in his remarks seemed to bear out this opinion, I would thank Mr. Pritchard to tell the meeting whether, in designing the reservoir, he made any provision for future requirements, and whether he considers that the available rainfall is utilised. These, Mr. President, are the only matters I wish at this time to direct attention; should other matters suggest themselves to me during the discussion, you will doubtless give me opportunity to speak again. I desire here to add my testimony to the skill and ability displayed in the design of these works, and to thank all those who have been instrumental in bringing about this visit—a visit rendered more interesting and instructive through the works being in progress.

The President: When Mr. Pritchard replies to the questions that have been put, I should be glad if he would clear up one or two other matters. I will mention them now, though not for the purpose of stopping the discussion, which I shall be very happy to hear continued. I understand the Snitterfield Brook does not discharge into the valley in which the reservoir is constructed, and that the water is abstracted from the brook, and transferred, by means of an adit or underground aqueduct, to a totally different watershed. I also understand there is to be no compensation either in water or money paid to the riparian owners on the brook. I should be glad to hear if there is any limit to the quantity of water to be taken; whether the Corporation may take all the water that flows down the brook, or simply the excess over and beyond the ordinary dry weather flow. It is stated that, in 1883, the gauge showed only 20 per cent. of the rainfall passing over the weir, at the proposed point of abstraction. I should be glad to know how long the gaugings were taken, and if the gaugings may be received as a fair and reliable data of the quantity likely to flow off. The total rainfall appears to be 27 inches, which is equal to 428,793,750 gallons per annum; but it seems that only 20 per cent. of this flows into the brook, which leaves 80 per cent. for evaporation. It would be valuable information to me, to know the separate cost of the tunnel 60 or 70 feet deep, the distance apart of the shafts during construction, and if it was found necessary to force fresh air into the tunnel to enable the men to work in it. If the shafts are at a considerable distance from each other, I fancy difficulty would arise as to ventilation during construction. With regard to the sewerage, it is explained the sewerage system is a mixed system; and therefore the whole of the sewage and the rain-water will pass to the sewage outfall tanks; this is a very important matter, as the whole of the sewage has to be pumped. Perhaps Mr. Pritchard will give the capacity of the tank sewer, and how much sewage and rainfall the tank will contain, and what becomes of it when the tank is full; and will he also explain if the effluent from the sewage farm would pass over other land belonging to the Corporation? if so, of course the sewage could be turned over that land likewise, and the effluent could be more effectually purified.

Mr. Pritchard: No; the sewage can be taken: but the effluent water goes direct to the river.

The President: We are told that the water from the canal permeates the water-supply pipes through part of the town. I suppose it is not to be understood that the canal water is supplied to the inhabitants for domestic purposes?

Mr. Davis: Certainly not, sir.

Mr. Coulthurst: It seems to be admitted that the reservoir might have been made of larger capacity.

Mr. Pritchard: No, don't say admitted.

Mr. Coulthurst: Well, it has been suggested that the reservoir might have been made of greater capacity. I see Mr. Pritchard has allowed for an average of 15 gallons per head per day. Any one who has had to deal with water supplies knows that if we have fittings of a stronger and better kind, and strict supervision, the average consumption can be brought down to that quantity, and even less. In a small town like Stratford it is very much easier to keep up a sharp inspection, and to insist on good and sound fittings, so that there shall be as little waste as possible, than it is in large towns, where the authorities will not allow a sufficient staff to be employed to carry out the work properly. With respect to the works we have to-day inspected, it has afforded me gratification and pleasure to go over them; and, from what I have seen of them, I think they will be of a first-class character, and fully adequate for the requirements of Stratford for years to come. I think the designs, and the manner in which the work has been carried out, reflect great credit on the engineer, the resident engineer, the contractors, and all concerned. Mr. Cartwright has touched upon the sewer ventilation, and Mr. Davis has stated his opinion that there is something wrong with regard to the system of open-shaft ventilation. I entirely differ from him there. In the first place, I do not think there has been any proper experience of the efficiency of open-sewer ventilation of Stratford, as I find there are but twenty-six open ventilators, and these are only on the main sewers. Unless you have ventilators distributed freely all over the place—I say every 50 yards—you will not do away with the evils arising from what I call contracted ventilation. If you ventilate at all you must do so efficiently, or you will be certain to have the nuisance complained of in Mr. Davis's paper. In Derby, whenever we have complaints of smells from the existing ventilators, we keep adding to the number. I myself am a great advocate for opening out, not only manholes, but gullies as well. We have some thousand or two open, we resort to flushing as much as possible, and we have very little complaint indeed.

The President: Do you go in for systematic flushing, and have you apparatus fixed for the purpose?

Mr. Coulthurst: Derby is an old town, and I should think twofifths are old dry brick sewers, and the flushing of course is frequent. During the present summer—the last half year—we used about 9 million gallons of water for flushing the sewers.

The President: Have you penstocks, or what?

Mr. Coulthurst: We have tanks in connection with the manholes, having a capacity of 600 or 700 gallons, and we have vans fitted with 9-inch-valve leather hose, which discharge about 400 gallons of water in three minutes.

Mr. Cartwright: I note that Mr. Pritchard expects to obtain the water from the adit so pure as to be able to send it into service without passing over the filter beds. The adit or pure-water pipe is laid in the same cutting as the conduit which conveys the brook water, and below and almost in immediate contact with it. The conduit is in brickwork, 9 inches, and the probabilities are, not perfectly water-tight; under these conditions may not there be some danger that the water from the conduit will escape, especially as when the reservoir is full it will be under pressure, and finding its way into the adit pipe be conveyed to the town direct. Two points in the construction of the embankment I would allude to, viz. the method of laying the discharge pipe across the puddle trench, and the proposition to lay a 6-inch layer of cement concrete over the slope: I submit to Mr. Pritchard whether there is not a danger of settlement in the former, and whether he does not fear the cracking in the latter as the embankment subsides.

The President: I suppose the layer of concrete goes all round.

Mr. Cartwright: My remarks apply to the artificial embankment.

Mr. Coulthurst: There is just one point I should like to raise respecting the 6-inch layer of concrete. It is whether Mr. Pritchard intends it to be a uniform surface of six inches, or intends to put it in steppes, and to make some portions deeper. That would obviate what Mr. Cartwright has suggested as a possible defect.

Mr. Pritchard: It affords me much pleasure, in the first place, to meet the Members of the Association in Stratford; and in the second place to afford any explanations; and if at the same time the visit to Stratford should prove to be instructive, it will afford me still greater pleasure. I think, in common justice, I should next acknowledge the ability with which both the papers, relating to the disposal of the sewage and the water supply, have been prepared. I will, in my remarks, endeavour to reply simply to those inquiries relating to the engineering branch of the works, and will ask Mr. Davis and Mr. Willcox to bear in mind and reply to any other point arising out of this discussion. There are many points raised, but gentlemen must forgive me when I say some of them are not of great importance. There are, however, other points raised of the greatest importance, and to these I will give my special attention. One important question has been raised by our respected chief, Sir Robert Rawlinson, in reference to the reservoir, and which other gentlemen have taken up, and have alluded to. Sir Robert did not venture an opinion that the reservoir was too small; he said that it was comparatively small for the work it had to do, and that, consequently, great care should be exercised (and whether small or large, I believe he would have said the same thing) in using the water and not wasting it. But, Mr. President, you have indirectly, and Mr. Cartwright has directly, made a point of the capacity of the reservoir. I think, sir, before suggesting that the storage capacity would be insufficient, careful consideration should be given to the data which determined the size of the reservoir, notably rainfall; flow of brook available for supplying the reservoir; and the quantity of water to be supplied by adits and other means entirely outside the flow of the brook. From the same geological formation although reservoirs were originally intended, I obtained a supply for the town of Warwick by water supplied by the adits alone, and reservoirs were unnecessary. By going down the valley, the reservoir for Stratford doubtless might have been considerably enlarged, though it would have entailed a much larger expenditure. Why, then, was the smaller reservoir constructed? I will tell you. From November 1882, until the gauging taken this very morning, gaugings have been taken of the flow from all sources likely to supply water to this particular basin; and it is with the knowledge thus acquired that I determined to construct the reservoir which the Members have this day inspected. The watershed of the Snitterfield Brook is very similar to the watersheds surrounding it in Warwickshire, some parts of Worcestershire, and other counties with which I am familiar. It would have been expected that from such a watershed, consisting for the most part of a retentive clay, over a retentive marl, we should have had at least 33 per cent. of the rainfall. Assuming 33 per cent. of the rainfall could have been obtained, we have a reservoir which, under ordinary conditions, without any other means of supply, would have been sufficiently large, or rather larger than what would be absolutely necessary. I find, however, that this watershed varies as compared with the drainage areas where I have been taking observations for many years, and situate upon the same geological formation. In 1883, with 22 inches of rainfall, there was gauged, as passing over the head sill, in nine consecutive months approximately 70 million gallons of water. This was equal to about 20 per cent. of the entire rainfall as being available for abstraction and retention in the reservoir. In 1884, with 22½ inches of rainfall, in twelve months a little over 53 million gallons of water were registered as passing over the head sill, and therefore available. Thus it will be observed with a rainfall of 22 inches in nine months we had 70 millions of gallons of water. With the same amount of rainfall extending over twelve months, we had only about 55 million gallons, showing the available water at the head sill as about 15½ per cent. of the entire rainfall. This shows conclusively that the watershed is not an ordinary one, and that in very dry years a small portion only of the rainfall will find its way to the reservoir from the surface of the ground. It is quite logical to assume that the other water will be found in the substratification. I think the President made an error when, on referring to Mr. Willcox's figures that only 20 per cent. of the rainfall was available, he said that 80 per cent. was lost by evaporation. That, I think, was the expression.

The President: I understood so, but it may admit of some other explanation.

Mr. Pritchard: There is nothing said in Mr. Willcox's paper about 80 per cent. evaporation, and 80 per cent. would be an abnormal quantity for evaporation. As there is only 20 per cent. at the sill head, of course there is 80 per cent. to be accounted for, not by evaporation, but rather by absorption and evaporation. There was 20 per cent. one year, and 15½ per cent. another year, passing over the head sill, being conclusive proof that a vast quantity of water passed off in some other direction. This led me to the conclusion that, as only from 15½ to 20 per cent. found its way into the brook, we should have a large volume from other sources. I therefore constructed the adit referred to in the paper; and I find at the present moment, when it is at its minimum flow (and not affected by the heavy rains we have had for the last few months), that we may rely on a quantity of water equal to about 40,000 gallons per day from the adit alone, which is nearly one-third of the required supply. Now that reduces the necessity for the reservoir capacity very much. An allowance has been made for evaporation equal to 15,000 gallons per day. The year 1884 was the driest year in this locality for some twenty years, and 1885 to the end of August (when we were troubled most for water) was even a drier year than 1884. At that time, in the reservoir, assuming it to have been constructed (without taking into consideration any of the additional water from the adit I have been speaking of), there would have been nearly 4 million gallons of water in reserve. That must, I think, be a most conclusive answer as to whether the data is reliable, or whether the reservoir is large enough, and I think must be considered a satisfactory answer to the question of small reservoirs. Mr. Cartwright suggested that what has been done is an instalment. Well, I do not object to the term. No doubt with a considerable increase in the population of Stratford it may be considered so, anyway it is sufficient for the purpose, and certainly no further instalment will be necessary for a population of 20,000 people, assuming the consumption does not exceed the estimated quantity and the adit flow is not reduced. The President raised an important question, and one of great interest to engineers, when he expressed surprise that, in any watershed in England, and more particularly in Warwickshire, water should be allowed to be abstracted from a brook without any compensation being demanded. The Corporation of Stratford are permitted to abstract the whole of the water from the upper portion of the Snitterfield Brook without having to pay anything, or provide one gallon of water as compensation. That I may say is chiefly due to the magnanimity of the Member for Bury, Mr. R. N. Phillips, who is the lord of the manor, and has met the Corporation of Stratford in every possible way. That is the explanation of the exceptional fact, that the Corporation are allowed to take even the whole of the water of the brook—though the whole of it will not be required because during rainfall there will be an excess of water—without having to give any compensation. Probably this fact of no compensation water will meet the objections of the previous speakers as to the quantity of storage.

The President: In dry weather you might take the whole of it.

Mr. Pritchard: Yes, in dry weather we should take the whole of it. The separate cost of the tunnel, perhaps Mr. Willcox may be able to give. The shafts were constructed at easy distances, as desired by the contractor; I think there were six as originally designed, but there are only two permanent ones, situate on the summit of the conduit. There has been no difficulty whatever in the ventilation.

The President: I mean whilst in construction.

Mr. Pritchard: Whilst the workmen were engaged, there was a difficulty with respect to ventilation, and a blowing machine was constantly used. The hardness of the water is a matter of importance, and has had the consideration of the town council; if the water contained carbonates or sulphates in the quantities as suggested by Mr. Cartwright, it would be totally unfit for use. The water proposed to be used will be about of the same degree of hardness as some of the water supplied to Birmingham, softer than that of Warwick, and much softer than the water supplied to the town of Leicester, which is not seriously complained of. The question of the hardness of the water has been dealt with by the county analyst, Dr. Bostock Hill, who is a very able chemist, who advised that the hardness is not excessive. The carbonates may be readily removed by boiling, and then the water is a comparatively soft one. The adit put under the conduit is one of those things seen before the work has been completed. The cast-iron main outside will be carried right inside the work, and there secured with concrete to prevent ordinary infiltration, should any leakage take place in the conduit itself; but as the conduit has been constructed as a tight culvert, I do not think there is any probability of such leakage. The inner slope of the reservoir will have 6 inches of concrete, three-fourths being in cutting; the concrete on the inner slope of embankment will be carefully formed with pillars from toe of embankment, to be constructed after the made ground has settled. As for a rainfall of 1½ inches being estimated and provided for in construction of sewers, I entirely disagree with the speaker. I think half an inch of rainfall an excessive quantity to make provision for. There is every provision made for storm water. We are told, with respect to ventilators, if one is offensive, put down two. I used to think so; I don't advocate it now. I consider, if there is an offensive emanation from the sewer, there is something objectionable in the sewer itself; and as I regard prevention as better than cure, it is better to remove the cause of the offensive smell. It must be clear to any one that, if there is foul gas from the ventilator, it proves the sewage is undergoing fermentation. That certainly is wrong; no one will deny that. Sewage with fermentation well developed should not be in the sewers at all, but should be discharged upon the outfall grounds in a fresh state, comparatively speaking. Mr. Davis has suggested that there may be some fault in the sewers at Stratford, and that may be the case. The open-grating ventilators at street levels at Stratford are so numerous, that you will find stinks at almost every point. I think what Mr. Davis stated has been misunderstood. He has placed vertical metal pipes at certain places to try and remedy this nuisance. I rather agree with what Sir Robert Rawlinson has suggested, that there is something in the sewers which creates this nuisance, and that, with the removal of old house drains connected with cesspools, the flow of water which there will be when the new waterworks are in operation, and the adoption of increased flushing, the nuisance will be greatly abated, if not entirely removed. The President inquired whether the sewage system is combined or not. It is combined, I am sorry to say, and I would prefer that the excess of water in the sewers should be subsoil water, instead of surface water. It is however, as explained, a combined system, and the outfall provides for a very large volume of sewage. The overflow of the supernatant water during heavy rainfall goes into the river in the ordinary course, except that it is strained before it passes from the outfall sewer to the overflow sewer. I cannot give details of the outfall reservoir sewer from memory; but I believe it would represent about 70,000 gallons capacity. Gas engines are used that they may be readily set to work at any time without requiring, as in steam engines, constant attendance. At present the engines only pump during the daytime and on week days; but it is proposed, I believe, to pump on Sundays. With the present discharge of sewage, I am of opinion that the reservoir sewer is found of sufficient capacity for the purpose.

Mr. Willcox (resident engineer, Stratford-on-Avon Waterworks): After the exhaustive explanation which Mr. Pritchard has given, there is very little I need say. The President has asked respecting the shafts. At first they were set out about 400 feet apart, but after a short while we found it would be advantageous to sink intermediate shafts, which was accordingly done. We had some difficulty with the ventilation, but by using what is called a "Blow George," we got a good supply of air into the workings. The cost of the conduit and adit was to have been 4186*l.* for the 1080 yards; but owing to the difficulties experienced as mentioned in my paper, in consequence of meeting with running sand, and also from other reasons, these figures are not reliable data as to the actual cost.

The President: Roughly it was about 4*l.* a yard?

Mr. Willcox: That also included the chambers at the intake. With regard to concrete on bank, I may say that some portion of the embankment is not made ground, but was formed by excavation below the original surface and trimming to the proper slopes, and this portion of the bank can at once be concreted if necessary; the excavated material went to form the remainder of the embankment.

Mr. A. T. Davis: Like Mr. Willcox, I can say that, after the very full reply Mr. Pritchard has given, very little remains for me to explain. I should like, however, to say that I feel very much obliged to Mr. Pritchard for the kind remark he made respecting my paper, which it has afforded me great pleasure to prepare and read. I am sure we all feel very highly honoured in having had Sir Robert Rawlinson here. As borough surveyor of this small town, I regard it as a very great compliment for Sir Robert to have attended. I am very glad he came, because he has stated, in the hearing of certain members of my Corporation, that it is advisable to do away with middens. This confirms my opinion, and will strengthen my hands considerably in dealing with these nuisances. As to emptying middens for every one, and cleansing manufactories at the public cost, I think that would be a bad precedent, and there is no knowing where it would end. A difficulty has recently arisen respecting the emptying of middens, and I have advised the Corporation to have nothing to do with them, but to abolish them and require the owners to construct water-closets. Mr. Cartwright asked what was the area that the town sewers drain. I think it is about 200 acres, but I cannot speak positively. Mr. Coulthurst misunderstood that portion of my paper respecting ventilation, but he has seen his error, so that I need not dilate upon that point. With regard to a question asked by the President, the whole of the surface water is taken into the sewerage system, and unfortunately has to be treated on the land. The farm is not yet out of the contractors' hands; but when it is, I am very sorry to say we shall have to deal with the surface water. It would be far better to have to deal with subsoil instead of surface water, because it would be a constant and known quantity, and would not come in a large volume when we do not want it. With regard to the capacity of the intercepting sewer, I have not calculated it, but I am told it is 70,000 gallons.

The President: It is of sufficient capacity to hold the accumulated sewage.

Mr. Davis: It is 3 feet in diameter, and is of sufficient capacity to hold the high flow of sewage. The canal water, which is in circulation in the water mains, is not used for domestic consumption. It was turned into the mains at my suggestion, because I considered we were running great risk in case of fire. That was really the chief reason why it was done.

The President: I beg to propose a vote of thanks to Mr. Willcox and Mr Davis, for the papers they have prepared and read to us. The papers contain a great deal of information, which must have occupied much time to obtain and prepare; and the discussion has certainly been useful to us.

Alderman Gibbs, the chief of the Stratford-on-Avon Sanitary Committee, on the invitation of the President, also addressed the meeting. He said: I have taken a great interest in these matters you have been discussing, having for a great many years been a resident of Stratford, and intimately connected with municipal affairs, and having for fifteen years occupied the position of chairman of the then Board of Health, until its dissolution in 1879. After the passing of the Rivers Pollution Act of 1875, we were placed in very considerable difficulty as to the disposal of the sewage, by the action of the riparian owners below the town. Complaint was made that the river Avon was polluted by sewage, and we were threatened from various quarters that action would be taken against us to compel us to take the sewage out of the river. We at once said that this would entail considerable expense. Thirty years ago, when the town was first drained, we were recommended by the authorities of that day to convey the sewage into the river, and now we are recommended, and may be compelled, to take it out. The question was, how to take our sewage out of the Avon at a small cost. Six or seven years ago, when Mr. Allen was the borough surveyor, we visited many towns in the Midland counties, and after going to Oxford, Windsor, Birmingham, and many other places, we came to the conclusion, having land near very well calculated to dispose of the sewage, that the adoption of the system recommended by Mr. Frankland was most desirable. Eventually we decided to consult Mr. Pritchard, who thought the general conclusions we had arrived at were sound; and it was decided that the sewage should be disposed of on the land selected. Then the water supply was defective, and it was thought desirable that a water supply should be provided from a satisfactory source, as the supply in the town was obtained mainly from shallow wells, which were liable to be polluted by middens and other nuisances which existed. A company was formed in London, to provide a supply of water for the town; but the Corporation thought it was desirable that the water supply should be in their own hands, and the Corporation bought the company out. Mr. Pritchard was then called in, and, after a great deal of consideration, came to the conclusion that the Snitterfield Brook was a desirable source of supply. Both as to the disposal of the sewage and the water supply, we have been entirely guided by the advice of Mr. Pritchard; and speaking on behalf of the Corporation generally, I may say we are very well satisfied with what he has done.

Mr. Pritchard: I should like to add before we leave, that the pumps are well worthy of consideration. When Mr. Ball sent in sketches, I was not greatly enamoured of them; but since they have been at work they have fulfilled every purpose for which they were intended. I do not think it is likely to get any pump to surpass them for the particular work which they have to perform.

During the day, visits were paid (1) *to the Waterworks at Snitterfield, including reservoirs, filter-beds and conduit in course of construction for the supply of water to Stratford.* (2) *To the Sewage Outfall Works on the Evesham Road, the Pumping Station and the Sewage Farm, where the various works were explained by the Engineer, Mr. Pritchard. The Members and the visitors attending the meeting were then entertained at luncheon at the Town Hall, by the Mayor.*

UNIVERSITY OF ILLINOIS LIBRARY

DISTRICT MEETING AT GATESHEAD.

December 12th, 1885.

Held at the Town Hall, Gateshead-on-Tyne.

Mr. R. Vawser, *President, in the Chair.*

The Mayor (Alderman McDermott) having welcomed the Members to Gateshead, and the President having suitably replied, the honorary secretary read the minutes of the previous meeting, which were confirmed.

Mr. P. W. Thomson was then re-elected Honorary Secretary for the Northern Counties District.

DESCRIPTION OF THE CAST-IRON CYLINDER FOUNDATION FOR A QUAY WALL IN THE RIVER TYNE AT GATESHEAD.

By JAS. BOWER, M.I.C.E., Borough Engineer, Gateshead-on-Tyne.

The construction of a quay wall when it is against the side of a tidal river or estuary, and where it is necessary to have a depth sufficient for merchant vessels to berth and float at low water, has many difficulties that require to be overcome, beyond that of constructing a wall of equal strength on dry ground, or in places where the contention with water is not called into question.

The simple excavation to low-water level, and the further taking out of still more excavation at the time of extreme ebb of spring tides as well as the hurried filling in with block masonry at such period, constitutes the history of many a useful wall which has been built by the river side, and which has been saved from damage by the shingle sloping away from it; but this form of wall is of no service for the merchant requirements of the present day.

The step next in advance is in the use of piling. This is often adopted. By means of a close set row of 12 or 14 inches square with backing piles at intervals—all cut off about low-water level and a planked floor placed on same—a foundation has often been obtained on which a masonry superstructure has been built, and a quay wall thus formed which is available with such depth of water at low tide as could be obtained by dredging in front of the piled apron. This can only be done to a very limited extent, as the outward thrust from the heavy superstructure becomes a serious force at a depth of only a few feet.

Another method by means of a cofferdam has been at times resorted to; but this in tidal water adds so much cost to the temporary works, and has but a narrow limit as to the depth obtained for foundation, that other expedients have to be adopted.

The idea of metal cylinders is one that seems to have been introduced some thirty years ago, and Dr. Potts took out a patent for the use of air pressure by which the water level in cylinder was kept from rising. This led further to the "air-lock" system, which is essentially of value when great depths are to be reached.

The cylinders used at the Gateshead quay were got down without any air-lock appliances, which is naturally a costly one in comparison to simple weighting of the cylinders if this can be got to effect the object.

The contract was let in 1882 to Messrs. Morrison and Mason of Glasgow, who provided three steam derrick cranes for their means of working, each of 10-ton power.

The cylinders were 7 feet 6 inches in diameter, of 1¼-inch metal, and were composed of rings placed on top of each other, each 5 feet high. These were all cast vertically in large moulds having very true loam cores, and accurately fitted in place to secure uniformity of thickness in the metal, and a length of from 6 to 9 inches extra height was cast on, so that any air-bubbles or foreign matter, dross, &c., should rise to this extra length portion. Each ring was placed in a suitable lathe and the edges were turned, the extra length being cut off; and in each end a groove was cut so that an indiarubber thong could be placed therein when setting one on the other.

Two flanges of 1½ metal as inside rings were cast on, one at top and one at bottom, having twenty-four holes in each; the top one had square holes specified and the lower one round holes, the object being to pass square-necked bolts up from below and tighten the nuts with a single spanner; of course these flanges were a trifle clear of the turned and grooved edges so as to secure a perfect contact, the indiarubber thong being laid first in the groove.

The contractors commenced by clearing away the shingle bed of river at low water to a level on which the first ring was placed, being slung into position with the derrick crane. This ring was a special casting, the lower edge being thickened and tapered on the inside of cylinder to become a cutting edge, the upper one being flanged inside, similar to all above it.

I would here remark that as a great deal of resistance in sinking was found to exist from friction on the sides as well as in penetration of the cutter, it appeared to me that a cutting edge slightly larger than the cylinder itself would in a measure so clear the way as to facilitate the sinking and avoid the intense friction referred to.

The first ring in place was covered by two or three others, which raised it about to high-water level; these after being bolted together were weighted with from 40 to 50 tons, and began to sink; this, after resting some twenty-four hours, was found generally to have sent the cutting ring down sufficiently so as to allow the cylinder to be *baled* out, and three workmen were then lowered to dig and loosen the inside earth, which being lifted up in "tubs" allowed a further sinking to take place—say the length of a ring below surface. The weights were then removed, another ring put on, and weights replaced, while the men inside the cylinder worked away to assist the sinking of the cutter. The water at times crept up inside the cylinder, so that men were obliged to give up; but by a patient delay with more "kentledge" or weighting, and taking low water of the next tide for baling out, the difficulty was in most cases met, and men again got to work inside.

By this means the cylinders were sunk to a depth of 47 feet below the quay level, which was equal to 25 feet below low-water mark.

The length of quay was 100 yards, and it was found that the cylinders could not be got closely in contact, so that one less than was contemplated was actually put down. It was found, after a depth of about 6 feet had been attained, that the cylinder had a will of its own, and sometimes this was a troublesome one, for if it were then out of the perpendicular it could not be got to return to it.

The difficulty of managing them when out of plumb can be readily understood, as the tubs could not be raised or lowered without great risk of contact with the inner flanges; but for this one would prefer a uniform "batter" to the cylinders if it could be secured.

In practice I found the cylinders had a tendency to batter in the wrong direction; but with one or two exceptions we were able with great care in the early starting to guard against this.

The material passed through was shingle, then sand, then clay with boulders in it at all depths, and some of these were very troublesome. Some four or five turned out were nearly large enough to fill a cylinder, and could only be dealt with by abrasion and fracture.

The contractors had a large stock of kentledge on hand, in the shape of cast-iron weights, about 9 feet across, 6 inches in thickness, having a circular opening 6 feet diameter in each, which they had used on a contract at Stobcross Docks in Glasgow for sinking large triangular concrete cylinders, and having a liberal stock at hand used them freely, so that there was as much as 160 tons at one time on one cylinder. So great was the strain on one set of cylinders, that a fracture took place in three rings, but it happened when nearly sunk to its permanent depth.

The rings were always built on sufficiently high to be well above high-water level, and involved a depth from top to bottom for lifting all the contents of not less than nine rings, or 45 feet in depth. These upper rings were removed as soon as the bottom was reached.

The filling with concrete was begun after about one-half of the cylinders were sunk, and the proportion specified was 6 of cement to 1 of broken brick, stone, or sharp gravel. The materials were all mixed by a mixing machine driven by steam power, and each charge measured in.

The quality of the cement was subject to the test of a tensile breaking strain of 330 lbs. per square inch of section in briquettes 1½ inch square, and only about four cargoes had to be rejected.

The cylinders were baled out by tubs, and men sent in to take out what sediment had lodged in since time of sinking, and they were allowed to fill, the water being at a state of rest; the concrete was lowered gently in cubic-yard hopper boxes, and the releasing bottom catch drawn back, which gently landed the contents in the cylinder.

In this manner the whole of the front cylinders were filled, and a second row of cylinders behind these at every fourth front one also; these second row cylinders were not sunk so low as the front ones by two rings, being only 15 feet below low-water level.

After the two rows of cylinders were sunk, the space between the back cylinders was excavated out to a depth of 8 feet below low water, the space being sheltered by a row of close 6-inch planking against the bank and the cylinders themselves. This was done only as low-tide time approached, and was a work of some difficulty. This space was filled in with concrete by hoppers as before, up to cylinder top level.

These spaces were found so troublesome to excavate in the short time by which men could be got into them, that a division of sheet piling was made to separate them in two, and thus it became more manageable; this cross piling was drawn generally after the first half was concreted and the second excavated, and before the second half of concrete went in.

The front row of cylinders, together with the back row and intermediate filling in, being completed, gave a foundation on which the masonry quay wall was afterwards built, of a width of 15 feet and depth of 25 feet at front and 15 feet at back.

The masonry front wall was of ashlar backed by concrete, and finished with a Heworth Burn coping 3 feet 6 inches broad.

The dredging in front of cylinders was taken out after the wall had been completed to a depth of 18 feet, and the effect on the line of wall was taken regularly twice a week while this was proceeding, and for three months after.

There was found at one place only a slight deflection of three-eighths of an inch in the coping, which was due only to the weight of wall taking its bearings.

The entire cost of the structure was 11,824*l.*, or equal to 118*l.* per lineal yard.

THE EFFICIENT DISCONNECTION OF SLOP-STONE PIPES.

By COSMO C. HOOLEY, Assoc. M. Inst. C.E.,

Surveyor to the Barton-upon-Irwell Union, Rural Sanitary Authority, Patricroft, near Manchester.

Although many elaborate schemes have been propounded with a view of improving the sanitary condition of towns and districts, minor details of great importance are overlooked, and the author would venture to bring before the notice of this Association one of those minor details which cannot with safety be neglected.

If careful inquiry was made into the existing condition of house drainage, a very glaring state of things would be revealed in the present system of disconnected slop-stone waste-pipes with drains.

It is now accepted as an invariable rule that such pipes should have no direct connection with the drains, and should discharge over a gulley which has a free communication with the outer fresh air.

The author has found numerous cases where no such provision has been made, and where the pipes are connected with the drains direct; of course, in all such cases, notice is served on the owner, and he is compelled to disconnect, but no approved method is in general use as a guide to its effectual disconnection.

The author has observed the various methods adopted by property owners and others, for effecting this disconnection, which it may be said are all more or less defective. The lead pipe is often carelessly fixed in the slop-stone, it is then brought down inside parallel with the outer wall, and has two bends before it reaches the point of discharge, causing the pipe to become stopped up at the bends, and in relieving these stoppages the connection between the pipe and slop-stone is often broken, and holes made in the lead pipe at the bends, causing a nuisance inside the house, and a soakage of sewage into the foundations. On the outside pipes have been found bent and distorted in all shapes, and in some cases, cut off flush with the face of the wall, so that the slop-water, instead of flowing on the gulley and into the drains, flows down the walls, down the back yards, and settles in pools, saturating with filth the ground adjoining the dwellings.

To defects of this kind typhoid fever can be traced, and cholera would be very severe and difficult to deal with under such circumstances. Very recently, the author's attention was drawn to a house where the slop-stone pipe was defective with all its attendant nuisances, and two cases of typhoid fever took place in the same house.

The author has found damaged pipes, mostly in houses occupied by the working classes, while in the better class houses he has seen the pipe and gulley boxed over and flower beds made with the intention of hiding the unsightly lead pipe which protrudes through the wall; thus reconnecting the drains with the house, and compelling all sewage gas escaping from the gulley to enter the dwelling.

The Members of this Association are familiar with the present method of disconnection in new property, but to any Member who will revisit property after some months of inhabitation, the above defects will be apparent, and to prevent this state of things, the author has adopted an appliance known as "Mounsey's Slop-stone Pipe Protector" which is a block of glazed earthenware tile, so formed as to be built into the wall of the house, into which the lead waste-pipe is made to fit, and no pipe is seen on the outer side of the wall.

The arrangement will be understood at a glance from the accompanying sketch, Fig. 1.

And as will be seen, the lead pipe from the slop-stone is fixed perfectly straight from the stone to the protector without any bend at all—which is the great advantage, and can be easily and readily cleaned by the tenant, if it should get stopped up.

In sketch No. 2, the author shows an ordinary slop-stone pipe as found in a house prior to occupation, and it will be noticed that it has two bends, which is entirely done away with in sketch No. 1, which the author has no hesitation in claiming as the best sanitary arrangement, and when provided with Mounsey's Protector may be said to be complete and impossible to get out of order.

The advantages to be derived from its adoption are :—

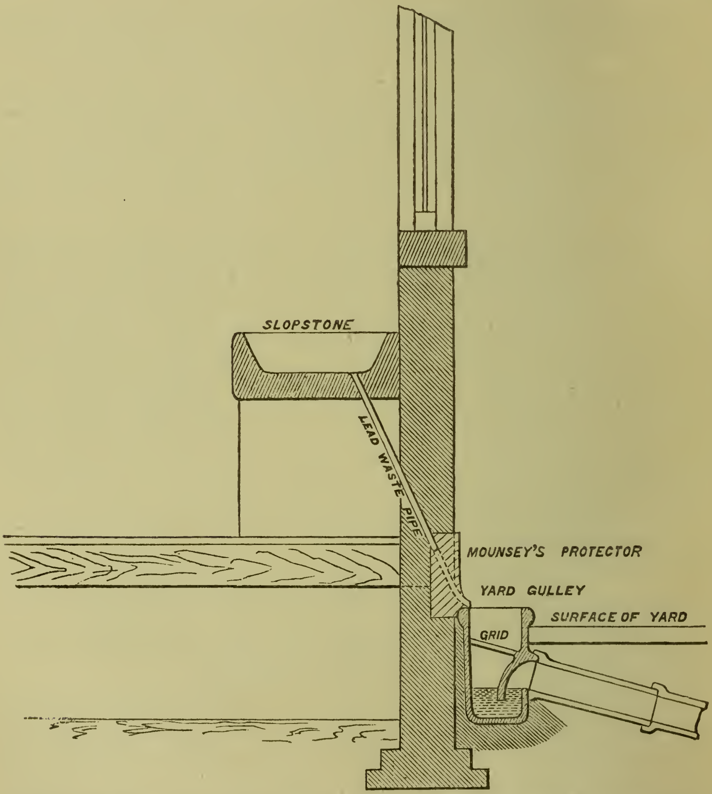
1st. By being at the side, instead of over the gulley, no gas is allowed to enter the house.

2nd. The lead pipe being encased and perfectly straight and six inches from the gulley grid, no gas from a dirty gulley can get into the house.

3rd. The grid of the gulley can be raised for emptying and cleaning purposes without interfering with or bending the slop-stone pipe.

4th. The neat appearance and impossibility of its being damaged or covered up by tenant, or meddled with by children.

Fig. 1.

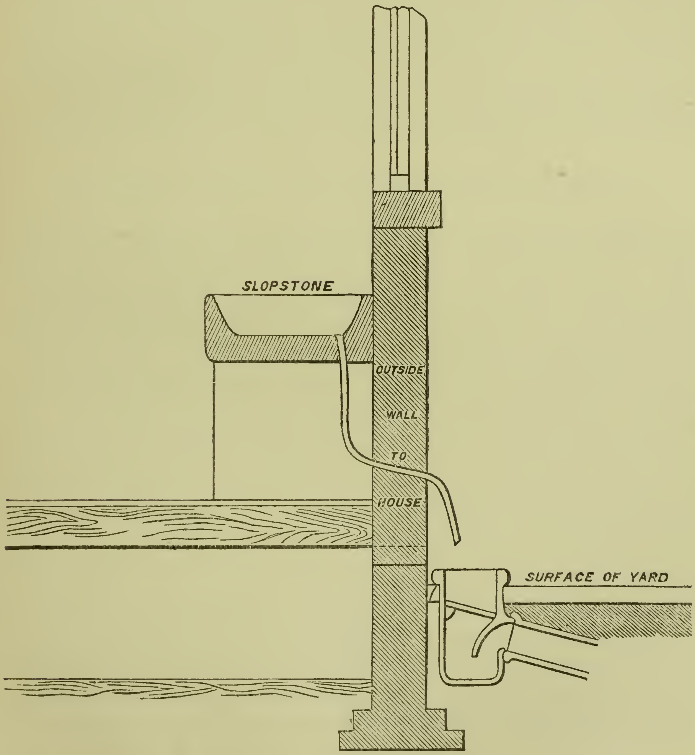


Improved Method of Disconnecting Slop-stone Pipe from the Drain.

5th. The prevention of sewage soaking into the foundations of houses, as is the case where a slop-stone pipe becomes defective.

The question will no doubt arise in the minds of Members of the difficulty of introducing an improvement to the ordinary builder, but in introducing this protector into the author's district, which is a large rural one within six miles of Manchester, his experience has been the reverse, and every builder who has seen it, has readily put them in his property. One case he met with in particular where a man who builds a considerable number of workmen's houses, and not celebrated for building first-class property, told him emphatically that he would always use them because they were cheaper than the long pipes.

Fig. 2.



In conclusion, if surveyors will adopt this method of dealing with slop-stone waste-pipes they will not only add to the health of their districts, but will considerably lessen the not over pleasant duties of the sanitary inspectors of their districts, who have often to compel property owners to replace or repair the slop-stone pipe to the gulley.

During the day, visits were paid to

(*a*) The North-Eastern Railway Workshops,

where the Members were courteously received by Mr. Sterling and Mr. Worsdell, managers, and shown through the various departments. The company were, first of all, conducted through the building shed, where engines of all sizes were seen in course of construction; and from there they passed to the other workshop, where the construction of locomotive engines was viewed in detail. As the Members passed through the various sheds, Messrs. Sterling and Worsdell explained the various modes of working, and drew attention to the more ingenious of the many wonderful machines seen in motion. Having visited every department, the company were conveyed in cabs to

(*b*) Hawkes, Crawshay, and Co.'s Works,

where they were introduced to the manager, Mr. Charlton, by Mr. Bower. The principal attraction at this place was a huge iron bridge which Messrs. Hawkes, Crawshay, and Company are building for a railway in Calcutta. The structure is in three parts, consisting of two arches and a central pier. The first arch is already finished and exported. The second arch, viewed by the company on Saturday, is in process of being taken to pieces previous to shipment. Mr. Charlton gave an interesting description of the bridge, in order to erect which in the yard of the company's works, a travelling crane had to be specially constructed at considerable cost. Mr. Charlton also gave a description of the proposed mode of erecting the bridge on its site. The bridge, which is intended to span a wide river, carrying two lines of rails, will be rivetted together on the banks of the stream, and the ends afterwards placed on the central pier by ingenious contrivances invented by the engineer of the railway. After leaving Messrs. Hawkes, Crawshay, and Co.'s Works, the Members were driven to

(*c*) The Gateshead Tramway Sheds.

Mr. Bower conducted the party through this place, explaining the working of the tramways, and giving such particulars as to the engines, carriages, &c., as were asked for. The Members were then driven to the Grey Horse Hotel, where they dined together.

DISTRICT MEETING AT BRADFORD.

April 10th, 1886.

Held at the Town Hall, Bradford.

Mr. R. Vawser, *President, in the Chair.*

Mr. J. W. Horsfield, Borough Surveyor, Batley, was re-elected Honorary Secretary for the Yorkshire District.

MUNICIPAL WORK IN BRADFORD.

By J. H. COX, Borough Surveyor, Bradford.

The first thought which is likely to present itself to the mind of any one preparing a paper on "Municipal work in a large town," is the almost limitless extent of the subject, and therefore it is quite impossible to give, within the scope of a short paper, anything more than a faint outline of the works undertaken in recent years by the Bradford Corporation.

Bradford derives its name from the Anglian words "brad" or "broad," and "ford" a passage over a stream. The town has contributed little towards the making of history, at any rate before the commencement of the present century. The chief historical events connected with the town occurred in Cromwell's time, when Bradford espoused the Parliamentary cause, and sustained two sieges from the Royalists under the Earl of Newcastle.

The town is situated somewhat peculiarly in the bend of a deep valley, which extends from the moorlands above Thornton, to the wider valley of Airedale, into which it merges at Shipley. The Bradford Beck runs through the heart of the town, where it is joined by its two tributaries the Eastbrook and Bowling Becks, and falls into the river Aire at Shipley.

The Becks, together with the coal, iron, and stone abounding in the district, have assisted materially in the development and prosperity of the town.

Its population at the beginning of the century was 13,264, and at the census of 1881 it had increased to 183,032.

In May 1882 the boundary of the borough was extended so as to include the townships of Allerton and Heaton, and the hamlets of Thornbury and Tyersal, containing an area of 3555 acres, and a population at the last census of 11,459. The total area of the borough as enlarged is 10,776 acres, and the population as estimated by the Registrar-General, to the middle of the present year, is 219,411.

The number of houses in Bradford in 1884 was 44,396, of warehouses 4353, and of mills 594. The rateable value of property within the borough is 949,231*l.*

The number of persons per acre is 20, but the density of the population in the various districts varies considerably; being over 100 to the acre in the West Ward, and only 2 per acre in the township of Allerton.

Although Bradford was incorporated in 1847, very little municipal work comparatively was done for some fifteen years afterwards, notwithstanding the fact that the population had increased so rapidly. The town was simply an overgrown village with exceedingly narrow and steep streets, and almost destitute of sanitary arrangements, but since then the Bradford Corporation may fairly claim to have been one of the most energetic and public-spirited sanitary authorities in the kingdom.

Street Improvements.

In 1863 the Council began in earnest to carry out extensive street improvements in the central portion of the town. Since then the re-modelling of the town has never ceased. Provisional Orders and Improvement Acts have followed thick and fast, until the borrowing powers for street improvements alone have reached the sum of 1,090,000*l.*; of this sum 1,023,367*l.* has already been borrowed and 205,097*l.* has been repaid through sinking fund. The period granted for repayment of the moneys borrowed under the several Provisional Orders amounting to 339,870*l.* is fifty years; but 100 years is allowed for repayment of moneys borrowed under the several Improvements Acts, amounting to 683,497*l.*

A Local Government Board inquiry was held in Bradford last week, to consider a further application by the Corporation to borrow 250,000*l.* for additional street improvements, 50,000*l.* for granite paving, 20,000*l.* for sewerage, 31,000*l.* for waterworks, and 12,000*l.* for public baths.

In acquiring property for street improvements, the Corporation have generally sought not only to take sufficient for making or widening the street itself, but also to provide enough land to form building sites to front such street. In doing so, much opposition has been met with ; but the point has been worth contending for, inasmuch as it has resulted in getting rid of a large number of cross rights of way, light, drainage, &c., which might have proved exceedingly troublesome. It has also assisted in recouping the Corporation in some cases by the sale of surplus land at an enhanced value and in securing the erection of a better class of buildings to abut upon such new or improved streets.

An important feature of the street improvement work in Bradford has been carried out under special powers contained in the 17th section of the Bradford Improvement Act of 1873, which empowers the Town Council to prescribe lines of frontage to be observed for any public thoroughfare in the borough. A similar provision on a smaller scale exists in the Public Health Act, Section 155.

It is provided under the 17th section, before mentioned, that such improvement line shall be distinctly shown on a plan to be approved by the Council and signed by the Mayor, and that such plan shall be at all reasonable times thereafter open for the inspection of the public. That whenever any new building shall be erected in any street where the Council have prescribed the line of frontage, or whenever the structure of the front of any old building shall be partially pulled down to the extent of one-third of such front, the Corporation shall be at liberty to require that as to such building the said line shall be observed. No new erection, excavation or obstruction shall be made beyond such line. In cases where the owner is injuriously affected, the Corporation are to make reasonable compensation, the amount of such compensation to be ascertained and determined either by the county court judge or by two of the borough justices, providing the latter are not members of the Corporation, and the said judge or justices have all the powers of an arbitrator under the Lands Clauses Consolidation Acts.

The penalty for wilfully or negligently acting contrary to this enactment is a sum not exceeding five pounds, and a further penalty not exceeding the like sum for every day during which such offence continues.

Sewerage.

The important works in connection with the sewerage of the town were commenced in 1862, under the supervision of Mr. Charles Gott, C.E., the then borough surveyor, and have been proceeded with without intermission up to the present time. Previous to their construction, the old badly-built rubble sewers discharged into the Beck, the latter had flood gates and weirs fixed across its course in order to divert the beck water into the old Bradford Canal basin which formerly received its water supply from that source; the consequence being, that during every tolerably heavy rainfall, the Beck was charged, and the lower portions of the town inundated, causing great damage to the goods of the merchants and tradesmen occupying premises there.

It has been estimated that the amount of money lost by damage caused in this way during three or four storms, would have sufficed to carry out the whole sewerage system at that date.

The gross length of public sewers completed since the commencement of the new sewerage system in 1862 is 72 miles 193 yards.

The main outfall sewer in Valley road is 8 feet 6 inches in diameter, circular in form, and previous to 1872 discharged into the Bradford Beck near to Manningham station. A second outfall sewer, 6 feet by 4 feet, egg-shaped, has since been made in the valley along the line of Canal road.

The total amount of money borrowed and expended for constructing main sewers up to the 1st instant, is 231,945*l.*; the term for repayment being fifty years, and the sum of 71,448*l.* has already been repaid through sinking fund.

Sewage Defecation.

In September 1868, Mr. W. R. C. Stansfield, the owner of Esholt Hall, an estate bordering upon the river Aire about four miles below Bradford, obtained an injunction from the Court of Chancery against the Corporation, the effect of which was to prevent the construction of any further sewers with an outfall into the Beck, or even the connection of any additional house-drains into the existing sewers having such an outfall, under a penalty of 10,000*l.* The injunction naturally caused serious inconvenience to the town, and the Council, after considering whether to move the Court to discharge the order, came to an agreement with Mr. Stansfield, undertaking, providing the injunction were made inoperative, to defecate the sewage of the town before the 11th January, 1872.

With this view the Corporation entered into a contract with the Peat Engineering and Sewage Filtration Company, whereby that Company engaged for a term of twenty-one years to purify at their own expense all sewage discharged at the outfall, upon the Corporation providing the requisite land and buildings. So confident were the Company that they would be able to dispose of the residuum profitably, that they agreed to pay the Corporation a small rental after the end of three years.

The process adopted, viz. filtration by peat charcoal, was a complete failure, the Company collapsed, and the Corporation took the concern into their own hands, retaining the services of the Company's engineer, Mr. Gustav Alsing, who at once set about to alter and adapt the works to suit the present process, viz. precipitation by lime and filtration through coke breeze. Since then the sewage has been satisfactorily dealt with in this manner.

Mr. G. Alsing is now engaged under the Corporation of Sheffield in constructing works for dealing with the sewage of that town on the same system.

The daily dry-weather flow of sewage is eight million gallons, and the quantity of lime used averages one ton per million gallons.

The works have been somewhat costly on account of the extensive alterations which have been required; but similar works, including all machinery and plant complete, could probably be erected for 40,000*l.*

The annual cost during the last few years of maintaining the works and defecating the sewage is 3200*l.*

Public Highways.

There are 118½ miles of public highways within the borough, 63½ miles being paved and 55 miles macadamised.

The total length of private streets is about 100 miles.

The granite setts used are chiefly 3 inches by 6 inches in dimensions, obtained from Mountsorrel and the Welsh Granite Company's quarries near Carnarvon. For the steeper roads 6 inch by 3 inch Dalbeattie granite setts have been used, in consequence of the better foothold which they afford for horses.

All granite pavement is laid on concrete foundations varying from 6 inches to 8 inches thick, composed of ground lias lime and broken stone in the proportion of 6 parts of stone to 1 of lime. The joints are grouted with asphalte.

The present cost per square yard of paving complete is 12*s.* 6*d.*

The cost of this work is charged to capital account. The amount borrowed and expended on permanent granite paving is 120,880*l.* repayable in twenty years, and the sum of 57,594*l.* has already been repaid through sinking fund.

The cost of forming and flagging the footways is charged to revenue account; they are laid with boasted kerb of local nell stone 12 inches deep and 10 inches wide, and self-faced flags 3 inches thick, obtained from the numerous quarries in the district. A footway flagged in the above manner costs in this district about 4*s.* 6*d.* per superficial yard.

A large number of streets are also paved with local nell setts 8 inches deep, and this class of paving affords a first-rate foothold for horses. In some cases it is laid on concrete foundations, and in others on foundations of broken ballast.

The cost of Yorkshire paving in Bradford, laid on concrete and the joints run with asphalte, is 7*s.* 6*d.* per square yard complete. If laid on a ballast foundation and the joints asphalted, the cost is 6*s.* 6*d.* per square yard; but even when laid on concrete the durability of this class of paving is not more than one-half that of Dalbeattie granite paving and not more than a third that of the Mountsorrel or Welsh granite paving. The cost of Yorkshire sett paving is paid for out of revenue.

Some ten years ago, random granite paving was introduced into Bradford in very large quantities; but as it did not meet with general approval, chiefly on account of its slipperiness and the difficulty of keeping it in decent repair in consequence of the great irregularity in the size and shape of the setts, its use was discontinued after a few years. The cost in Bradford of this class of paving was about the same as that of Yorkshire sett paving.

The macadamised roads are repaired with limestone, and about a mile in length has been laid with tar macadam; the latter has given such satisfaction, that it is intended to extend the use of it very considerably during the ensuing summer.

Private Street Improvements.

Prior to 1870 the amount expended on private street improvement works did not exceed some 2000*l.* to 3000*l.* per year, and the sanitary condition of the town suffered greatly in consequence.

Since 1870, this department of work has been greatly extended, and from that year up to the end of 1885, no less than 612 streets or a total length of 51 miles have been paved, and the sewers reconstructed where necessary, at a cost of 271,402*l*. This amount has been duly apportioned amongst the respective property owners. During the first few years of this period, this class of work was executed by contractors, but since then the Corporation have employed a special staff of workmen for the purpose, which has resulted in the work being more substantially done, with much better materials, and at very little additional cost.

In nearly all cases the property owners interested, prefer the work being done by Corporation workmen; and after the accounts are settled, it is the practice of the Corporation to adopt such streets as highways repairable by the public.

Tramways.

The Corporation obtained powers in 1880 to construct tramways on three routes, viz. Manningham Lane, Leeds Road, and Sunbridge Road, having a total length equal to 7½ miles of single line.

Previous to commencing operations, tenders were invited for leasing and working the lines when complete; and ultimately they were leased to Messrs. Turton, Mason and Busby, of Leeds and Liverpool, for twenty-one years, at an annual rental of 290*l*. for the first ten years, and 300*l*. a year for the remainder of the term, equal to about 7¼ per cent. on the outlay. The concern has since been converted into a limited liability company, and now pays a dividend of 10 per cent.

The gauge is 4 feet. The rails were provided and laid by contract by Messrs. Ridley & Co., of Newcastle, at 1998*l*. per mile of single line, exclusive of points and crossings, and the latter were made out of the rails themselves by Messrs. Thwaites & Co., of Bradford, at the price of 8*l*. per pair of points and 4*l*. for each crossing, Messrs. Ridley & Co. furnishing the rails for the purpose.

The concrete foundation and granite paving were laid by Corporation workmen, and cost 2500*l*. per mile.

The various systems of tramways in operation at the time were well considered, and two were chosen as being superior to the rest, viz. Gowan's, as laid in Manchester, Bolton, and other places, and Winby and Levick's system as laid in Nottingham and Newcastle.

As it was proposed to work some of the tramways by steam, the author had a preference for the Gowan rail; but Messrs. Ridley, of Newcastle, the proprietors of the Winby and Levick's rail, and several of their agents, were so assiduous in setting forth the advantages of their system, that the Corporation finally decided to adopt it for the first instalment of the Bradford Corporation Tramways.

It consists of a steel rail 6 inches high with a bottom flange 3½ inches wide, weighs 65 lb. to the yard, and is rolled in lengths of 24 feet. These rails are mounted on wrought-iron base plates, each 12 feet long, 12 inches wide, and ⅜ inch thick, and are secured thereto by means of cotter bolts and cotters, at intervals of 2 feet on alternate sides of the rail.

The Manningham Lane section was opened on the 31st January, 1882, and has since been worked exclusively by horse power.

The Leeds Road section was completed on the 7th June, 1882. It is 1 mile 1233 yards in length, and consists of single line with seven passing places, the latter being each 72 yards in length.

The Sunbridge Road line was completed on the 9th September, 1882; the length of route being 1 mile 1329 yards, including 1705 yards of double line, and 1384 yards of single line with four passing places.

The two latter sections are worked by steam power as the gradients are somewhat severe, being 1 in 22 for the greater part of the distance on the Leeds Road route, and 1 in 16¼ for a distance of 190 yards on the Sunbridge Road route.

The Manningham Lane line is still in very good order; but the two other sections, where steam power has been used, have suffered considerably.

The engines first used on these lines, were built by Messrs. Kitson, of Leeds; and although in many respects they did their work very well, the Corporation have frequently had cause to complain of the damage done to the permanent way, in consequence of the extraordinary oscillation of the engines. The tramway gauge being only 4 feet wide, the cylinders were placed outside the two front driving wheels of the engine, and the latter being somewhat short in length, every movement of the piston backwards and forwards in the cylinders, imparted a kind of waddling motion to the engine, which has had a very detrimental effect on the rails and the adjoining paving.

In 1882 the Corporation decided to apply for further powers for tramway extensions, and a Provisional Order was obtained in the year following for laying about 6½ miles of additional tramways, of which 2½ miles was double line, and 4 miles single line.

The principal route under this order was the Manchester Road line. This road is one of the most important thoroughfares in the borough, 2 miles in length and somewhat steep, as indeed are most of the main approaches to the town. The tramways committee had by this time gained considerable experience as to the trouble and expense of maintaining tramways worked by steam, so that there was little difficulty in persuading them to discard Winby and Levick's system, and substitute what is known as Gowan's rail.

A contract was entered into with the Barrow Steel Co. to supply Bessemer steel rails of the girder pattern, 7 inches deep and 7½ inches bottom flange, weighing 103 lbs. to the yard, at the price of 8*l.* 10*s.* per ton delivered at Bradford. Two further contracts were subsequently made with the Barrow Co., whereby similar rails were supplied at the reduced rates of 7*l.* 18*s.* 9*d.* per ton and 7*l.* 16*s.* 3*d.* per ton respectively.

The rails were rolled in 30-feet lengths, and the contract for laying them was let to Mr. Clifford E. Winby, of Rochdale, at the rate of 1722*l.* per mile, exclusive of points and crossings, the Corporation undertaking to run in a layer of pitch under the rails, and to fill in the hollow sides with cement. The points were each 12 feet in length, and the crossings 5 feet; made out of the rolled rails by Messrs. Thwaites Bros., of Bradford, at the price of 11*l.* per pair for points, and 4*l.* 10*s.* each for crossings; the Corporation providing the rails for the purpose.

The foundation for the roadway was laid with a bed of concrete 6 inches in thickness, composed of broken stone and lias lime in the proportion of 6 to 1; the surface of the concrete for the width of the tramway was floated to a smooth face, and the rails laid thereon; but as it was found impossible to make the bottom flange of the rail to touch the concrete at all points, it was decided to run a thin layer of pitch underneath to fill the intervening space. This proved to be well worth doing, and has given great stability to the line.

The rails are fished with steel fish-plates, 16 inches long, weighing 22 lb. per pair, and are bolted together with strong bolts 1 inch diameter, and nuts to match, each bolt and nut together weighing 1 lb. 5 oz. These bolts may appear to some people to be unnecessarily heavy; but experience in Bradford has proved conclusively that they are not a bit too strong for the extraordinary heavy work they have to undergo.

Although the carriage-way is paved from kerb to kerb, tie rods 1¼ inch by ⅜ inch with screw ends ¾ inch diameter and double lock nuts on each end, have been inserted at intervals of 15 feet to assist in keeping the line to gauge.

It was intended at first to dispense with the use of tie rods; but as the contractor offered to put them in at an additional cost of 30*l.* per mile, the committee were tempted to use them.

Shoe plates of wrought iron ½ inch thick and 12 inches square have been placed under the ends of the rails to prevent one rail sinking below another at the joints, and cast-iron wedges of ¾ inch metal have been used to fill in the angles caused by the points and crossings.

The sides of the rails were plastered flush with the top flanges, with a mixture of Portland cement and river sand, in order that no hollow space should be left between the rails and the setts abutting thereon.

The whole carriage-way including the width of the tramway was paved with Mountsorrel setts 3 inches by 6 inches, except in one short portion where the gradient was 1 in 19, when 3 inch by 6 inch Dalbeattie granite setts were used. The joints of the paving were grouted with a mixture of hot tar and pitch.

Operations were commenced on the 21st of April, 1884, and completed on the 5th of September, on which latter day Major-General Hutchinson made his official inspection of the line, and expressed himself highly satisfied with the substantial manner in which the works had been carried out.

This section of tramway cost 4500*l.* per mile of single line, being 1930*l.* for tramway proper and 2570*l.* for paving.

The total amount borrowed for the construction of tramways in Bradford to this date is 51,985*l.*, and the term for repayment is thirty years.

This line is leased to the Bradford and Shelf Tramway Company for a term of twenty-one years, at a rental of 400*l.* per mile of single line per annum, equal to about 11 per cent. on the outlay.

This company has been very successful so far, and has paid a dividend of 10 per cent. to the shareholders. The journey of two miles is worked in two stages, and 1*d.* fare is charged for each stage.

Engines.

The Manchester Road line is worked entirely by steam power, seven engines being provided for that purpose. They have all been made by Messrs. Thomas Green and Son, of Leeds; the earlier ones having vertical boilers, but those made the most recently, and which give the most satisfaction, are of the locomotive type, and can be driven from either end; the cylinders are inside or between the wheels, and the wheel base is 5 feet. Cylinders 9 inches diameter and 14 inches stroke. Automatic brakes are provided, and air condensers are fitted on the roof.

The engines weigh over 8 tons, and cost 800*l.* each. The consumption of coke is 13½ lb. per mile run.

The average cost of wages, fuel and oil per mile run is 4*d.*, and the cost of renewals averages 1*d.* per mile run. Total working expenses, including rent, rates, gas, water, wages, stores, renewals, &c., equal 9*d.* per mile. This is exclusive of engines, cars, and buildings which come under the head of Capital Account. There are seven large cars fitted with bogie wheels employed on the line, and each car is capable of seating fifty-eight passengers, and cost 237*l.* 10*s.*; there are also seven smaller cars, with fixed wheel base, capable of carrying eighteen passengers.

The cost of the small cars was 132*l.* each.

Markets.

In the preamble to the Bradford Corporation Act 1866, it is set forth that the markets and fairs held within the borough are or are claimed to be franchises of the manor of Bradford which comprises the borough.

That the accommodation is inadequate, and not suited to the wants of the borough.

That the annual fairs, two of which extended over several days, were held in the streets, the foot pavements of which had to be barricaded from the carriage-way by the Corporation for the protection of foot passengers, and that the ordinary traffic of the streets was seriously interrupted.

That the Corporation were desirous of taking a lease for a long term of years of the markets and fairs and the market-places, and

That the lady of the manor was willing to grant a lease thereof for 999 years at a yearly rent of 5000*l.* if she be thereunto authorised by Parliament.

The right of appointing an inspector of weights and measures was also claimed to belong to the manor, and as great inconveniences sometimes resulted from the exercise of this right, it was also to be included in the lease.

It is further set out in the preamble that it would be expedient for the Corporation to be authorised to purchase compulsorily other lands and estates and interests, and to provide other market-places, and places for fairs, and to erect market-houses, slaughter-houses, and other works and conveniences, and to be able to appropriate portions of their purchases for approaches and street purposes and to be able to prohibit and prevent any other person or persons from exercising or interfering with the market franchises within the borough.

To enable the Corporation to carry out their purchase and to develop the market estates, it was proposed to borrow the sum of 150,000*l.*, repayable by sinking fund in fifty years.

The Act obtained the Royal assent on the 16th of July, 1866, and in the September following the Corporation had the property and rights handed over to them.

The property consisted of about 18,621 square yards of land in the neighbourhood of Kirkgate, Darley Street, Rawson Place, Duke Street and Manor Row, upon which were erected the old manor-house, shops, dwelling-houses, public-houses, the old theatre-royal, the market-house buildings and the stalls of the market tenants, and the first year's revenue from all sources was 4133*l.* 13*s.* 6*d.*

As was intimated in the preamble of the Bill, it was soon found necessary to begin alterations, and one of the first improvements was the continuation of Godwin Street through the Rawson Place part of the market estate to Darley Street. This somewhat interfered with the approaches to and the conveniences and capacity of the slaughter-houses which had long been a standing disgrace to the town; and as it took away some 1000 yards of the land used for market purposes, the markets committee soon found that it was necessary to procure other land to which they could remove the wholesale vegetable and fish market and the cattle markets and fairs, and slaughter-houses. For this purpose some 48,500 square yards of land was purchased adjoining the Great Northern Railway station on the southern side of the town, now known as the St. James's markets, the enclosing and adaptation of which by Mr. Gott together with the purchase money cost about 22,500*l.*

Of this estate about 7000 square yards has been devoted to slaughter-houses and carcase market purposes, and the buildings already erected thereon have cost about 14,500*l*.

About 18,150 square yards are occupied by the wholesale vegetable and fish markets and the railway sidings in connection therewith, and about 23,000*l*. has been expended in the erection of potato warehouses, fruit and fish shops, market-gardeners' stands, &c. The remainder of the site is available for fair ground purposes and for future extension of the market.

In addition to the St. James's slaughter-houses already mentioned, the Corporation in 1873 purchased the Bolton Lane abattoirs from a company of butchers for 10,000*l*. The site contains about 8550 square yards, and since their acquisition the Corporation have expended about 8000*l*. more upon them in extensions and sanitary improvements.

Mr. Gott was also instructed to lay out the estate which the markets committee had acquired from the lady of the manor, and did so by showing the desirability of erecting what are now known as the Kirkgate and Rawson Place markets, and surrounding them with shops and other buildings, and appropriating the remainder of the estate for street improvements and building purposes.

Every building which was standing upon the estate of the lady of the manor when the Corporation took possession has been pulled down, except one block of two dwelling-houses in Manor Row. The plans originally laid down by Mr. Gott have been pretty closely adhered to, and during the last nineteen years the markets committee have been busily engaged in carrying them out, and have exhausted the whole of the 150,000*l*. which they were authorised to borrow.

The Kirkgate market, which covers an area of about 5000 square yards, cost in building 42,000*l*. and the exterior buildings by which it is surrounded have cost 47,000*l*. more.

This block forms one of the handsomest piles of buildings in the town, and includes the Free Library and Art Museum.

There are 218 shops and stalls in the interior of the Kirkgate market, which are all well let at satisfactory rentals, as indeed is every other part of the market estate.

The Rawson Place meat and fish market covers an area of about 2320 square yards, and cost in building about 18,500*l*.

From the foregoing details it will be seen that the markets' department of the Corporation of Bradford has been exercising an important influence in the development of the town and its market accommodation, as in addition to the 5000*l.* per annum which has to be paid to the lady of the manor, they have expended in land and buildings 159,000*l.* and they have not yet done if the suggestions which are continually being made are to be carried out.

Although every part of the estate is not yet fully developed or built upon, and a large area of very valuable surplus land is open for sale for building purposes, it may be said that for the last few years it has been able to pay its way; the calculation being that for the year ending December 31st, 1885, the total revenue, which amounted to 17,416*l.* 0*s.* 4*d.*, was equal, after paying all expenses, to about 4¼ per cent. on the capital invested.

It is found that some parts of the estate pay better than others; for example:—The wholesale vegetable and fish markets pay about 6 per cent. The Kirkgate general and retail market 5 per cent. The Rawson Place meat and fish retail market 3½ per cent. The exterior buildings around the retail markets 5 per cent., and the slaughter-houses 4 per cent., the surplus building land at Darley Street and Rawson Place and the land reserved for the fairs, and the future extensions of St. James's markets, being the weights which keep the interest down at present.

The rights and franchises of the lord or lady of the manor were somewhat peculiar in the case of Bradford, and the development of the town might have been seriously impeded, had the Corporation not arranged for the purchase of the manorial rights of the markets and fairs.

As it is, the central covered markets have now become a very attractive feature in drawing people into the town, as in all states of the weather it is known that they can be resorted to conveniently.

The railway facilities into the St. James's vegetable and fish markets have no doubt had an important influence in supplying the town and neighbourhood with cheaper vegetables, fruit and fish, and have materially influenced the development of the business carried on in this part of the market estate.

The erection of public abattoirs and carcase markets seems to be the proper thing to do from a sanitary point of view, as the animals whilst alive are better cared for than they otherwise might be, and a better supervision can be exercised as to the wholesomeness of the meat offered for sale in the town.

Public Parks.

Peel Park.—This park contains an area of about 56 acres, and is beautifully situated in the valley which divides the townships of Bolton and Bradford.

The nett cost of the land for the park was 6000*l.*, and a similar sum was spent in laying out and planting the grounds. The money was raised by public subscription, and in 1863 the park was handed over to the Corporation entirely free from debt.

Lister Park and Mansion, in the township of Manningham, formerly the residence of Mr. S. C. Lister, was sold by that gentleman to the Corporation in 1870 for 60,000*l.*, towards which Mr. Lister contributed 20,000*l.* on condition that the park should be set apart for the free use of the public. It is a finely timbered piece of ground, and contains an area of 54 acres.

By the Bradford Improvement Act 1875, the Corporation were empowered to provide two parks in other portions of the town, viz. Horton Park, containing 39 acres, opened in 1878, and Bowling Park, containing 53 acres, opened in 1880.

A small park, containing 15 acres, has since been enclosed and laid out at Bradford Moor.

In addition to the above, the waterworks committee have thrown open, for the use of the public, the beautiful grounds in connection with the reservoirs at Chellow Dean, which answer the purpose of a park for the Allerton district.

The parks, which are very evenly distributed throughout the borough, are maintained in good order, and are well provided with handsome lodges, conservatories, and other erections; and band performances, supported entirely by voluntary contributions, take place twice a week during the summer months, in each of the four parks first mentioned.

Cemeteries.

The first cemetery in Bradford was established by the Undercliffe Cemetery Company in 1852.

By an order of the Privy Council, most of the Church and Chapel burial grounds in Bradford were closed in 1855, and the question of providing cemetery accommodation was shortly afterwards forced upon the Corporation, who purchased a site at Scholemoor, containing 30 acres, for 4750*l.*

The laying out of the cemetery was entrusted to the borough surveyor, Mr. Gott, and cost about 6000*l.* A small portion has been set apart and purchased by the Jewish community for the interment of Jews, and a few acres still remain unappropriated.

Scholemoor Cemetery was opened in August 1860.

In 1881, in consequence of the rapid diminution of burial places within the borough, the Corporation decided to purchase 62 acres of land adjoining Bowling Park for the sum of 17,280*l.* as a site for a public cemetery for the southern portion of the town. Premiums were offered publicly for the best design for laying out the grounds, and the plan prepared by Mr. George Heaton of Wigan was selected, and a contract amounting to 5378*l.* was immediately afterwards entered into with Mr. Lister Kershaw of Brighouse for carrying into execution a portion of the design covering an area of 22 acres. The chapels, lodges, entrances and greenhouses are now being erected at a cost of 7100*l.*, according to designs prepared in public competition by Messrs. Morley and Woodhouse, architects of Bradford.

Sanitary Department.

Amid the manifold improvements carried out by the Bradford Corporation, one great blot still remains. The privy and midden stead system continues to flourish, though in a more refined and improved state than formerly.

True, many improvements have been introduced, such as reducing the size of the ashpits, covering and ventilating them, making emptying doors whereby workmen might empty the ashpits from the outside, making water-tight bottoms with concrete and flags, discarding the drains, &c.

Subsequently blocks of four privies with one large common ashpit were prohibited, and privies were erected in couples with a much smaller ashpit between them, and the privy seats hung with hinges.

An attempt was made, by means of a wrought-iron grating fixed across the ashpit immediately below the cill level of the throwing-in door, to separate the finer ashes from the rougher refuse, by allowing the former to fall through the grating on to the excreta and retaining the coarser ashes, broken pots, and other refuse on the top; the object in keeping them separate being to send the former to the farmers, and the latter to the tips or destructor kilns. The iron grating arrangement has not been very successful; but the scavengers in removing ashpit refuse manage tolerably well to keep the two kinds of refuse separate.

The late Medical Officer of Health protested against the privy and midden system, and expressed his opinion, in one of his reports to the sanitary authority, as follows:—"In Bradford we labour under the disadvantage of a system of night scavenging, which, having started on false principles, cannot be made satisfactory by mere improvements of detail."

The present medical officer, Dr. Hime, in his admirable report on the health of Bradford, recently issued, says:—"The use of such middens in a large populous town can be justified on no sufficient grounds; it is a violation of the fundamental principles of hygiene and sanitary science."

As the privies are tolerably well built, the author has more than once suggested to the sanitary committee the desirability of converting a number of them into water-closets as an experiment; but the suggestion has found little favour, chiefly no doubt on account of the already large expense which has been imposed on the owners of cottage property, and also in view of the rapid decrease in the Bradford death-rate.

The privy and ashpit system will find few if any advocates amongst the Members of this Association; but if, instead of spending much time to-day in flogging such a dead horse as the midden system, any gentleman present can point out any towns or places where privies have been successfully converted into and used as water-closets, or can give any information as to the successful working of water-closets, as distinct from trough closets, in small outbuildings built quite apart from the house, or as to whether any difficulties are likely to occur during severe winter seasons, by reason of the freezing of water in cisterns, pipes, pans or traps, or from any other cause, the author would feel deeply obliged for the information.

Removal of Night Soil and Ashes.

During the year ending on 30th of September last, the contractors emptied 52,826 ashpits and removed therefrom 22,931 loads of soil and 40,279 loads of rubbish, or a total of 63,210 loads.

This work is done by contract; and in July last, the sanitary committee, after advertising for tenders, decided to relet the work for a further term of three years to the old contractors, Messrs. Greenwood Brothers, for the sum of 6800*l.* for the first year, 7200*l.* for the second year, and 7500*l.* for the third year, or a total sum of 21,500*l.*, being 2000*l.* less than the amount for the preceding three years. The decrease is mainly owing to the greater facilities afforded to the contractors by the improvements made for emptying the ashpits and also for the improved approaches thereto.

Sixty railway waggons are kept by the Corporation for conveying the soil into the farming districts, and 29,880 loads of ashpit refuse have been dealt with at the Hammerton Street and Southfield Lane destructors.

Refuse Destructors.

Fryer's destructor at Hammerton Street comprises two blocks or kilns of six cells each, the chimney shaft being placed between the two kilns. Each block contains three cells to the front and three to the back, with the main flue between them leading to the chimney shaft. The latter is 180 feet high, and has an internal diameter of 7 feet 6 inches at the bottom and 6 feet 6 inches at the top.

Destructor kilns have already been described so fully in the Proceedings of this Association, that it is quite unnecessary to repeat the description here.

The refuse is tipped in at the top of the furnaces, and after undergoing the drying and burning process, is drawn out at the front in the form of clinker. In order to ascertain precisely how much the refuse was reduced in weight and bulk by passing through the destructor, a careful account was kept for a period of five weeks, during which 2040 loads of rubbish weighing 1866 tons was burnt, leaving a residue of clinker amounting to 502 loads weighing 685 tons.

It will be seen from this that the burning process reduces the refuse to about one-fourth in bulk, and about one-third in weight. The average number of loads burnt per day of 24 hours is 88, equal to 7¼ loads per cell; on Saturdays the number is 40, the works being closed in the afternoon and on Sundays.

The quantity of refuse destroyed at Hammerton Street during the last year is as follows:—23,407 loads of ashpit and other refuse, and 690 loads of market garbage and refuse from fish dealers, making a total of 24,097 loads; the carcases of 11 beasts, 2 calves, 4 sheep, 79 pigs, 6½ tons of fish, 82 baskets of cherries, 90 bags of cockles, 2 bags of mussels, 11 tins of tongues, 9 cheeses, and a large quantity of infected bedding.

The heat from the destructor is utilised by being passed through a multitubular boiler on its way to the chimney shaft, thus providing the steam for a 16 horse-power engine which drives three mortar mills. The clinker is ground up in these mortar pans together with due proportions of lime and water, and makes exceedingly good mortar. The Corporation works are all supplied with both lias lime mortar and common lime mortar from this source, and the public are also supplied at the price of 8*s.* per ton for the lias mortar and 6*s.* 6*d.* per ton for the ordinary mortar. The total weight of mortar sold during the year is 3737 tons, and the receipts for same amount to 1044*l.* 13*s.* 10*d.* The following is a statement of the working expenses at the Hammerton Street destructor:—

	£	*s.*	*d.*
Wages, 11 men	676	0	0
General repairs	109	0	0
Lime	358	0	0
Coal for men's mess-room	5	13	10
Gas	59	16	2
Water	34	3	1
Oil and tallow	40	0	0
Books, stationery, &c.	4	12	0
Boiler insurance	2	5	0
Total	£1289	10	1

TOTAL COST OF THE DESTRUCTOR, 12 CELLS, INCLUDING BUILDINGS, CHIMNEY SHAFT, APPROACHES, PAVING, GAS, WATER, AND MACHINERY.

	£	*s.*	*d.*
Ironwork and royalty	1888	0	0
Brickwork for 12 cells	418	10	0
Chimney shaft (180 feet high) and lightning conductor	650	0	0
Buildings, paving, gas, water, &c.	4800	0	0
16 horse-power engine and shafting	246	0	0
Multitubular boiler	360	0	0
Three mortar pans	280	0	0
Total Cost (exclusive of land) ..	£8642	10	0

Land covered by destructor and approaches, 6500 sq. yards, at 10*s.*

Healey's Destructor.

The Southfield Lane destructor has four cells, only three of which are used at one time; it is known as Healey's patent, and is very similar in many respects to Fryer's.

The cost and amount of work done are proportionately the same.

The quantity of refuse dealt with in the three cells amounts to 5784 loads, exclusive of twelve pigs and various quantities of diseased meat and infected bedding.

The Beehive Destructor.

This furnace was erected with a view of destroying the market garbage and fish refuse, but as the cost of wages and fuel amounted to over 4*s.* per ton of refuse destroyed, its use was discontinued, and arrangements are now being made for grinding the market refuse in a mortar pan, as practised at Nottingham, and sending it into the farming districts for manure.

Mortality Returns.

The annexed diagram, enlarged from a similar one accompanying Dr. Hime's report for 1884, shows very strikingly the decrease in the rate of mortality within the borough during the last twenty years.

The shaded portion of the column represents what the late Dr. Farr considered might be regarded as the normal annual death-rate of a healthy town, viz. 17 per 1000, therefore the black portion of the column shows by how much the death-rate in any year exceeded this normal rate for a healthy town.

Table C shows the births and deaths, the latter from all causes and also from the principal zymotic diseases.

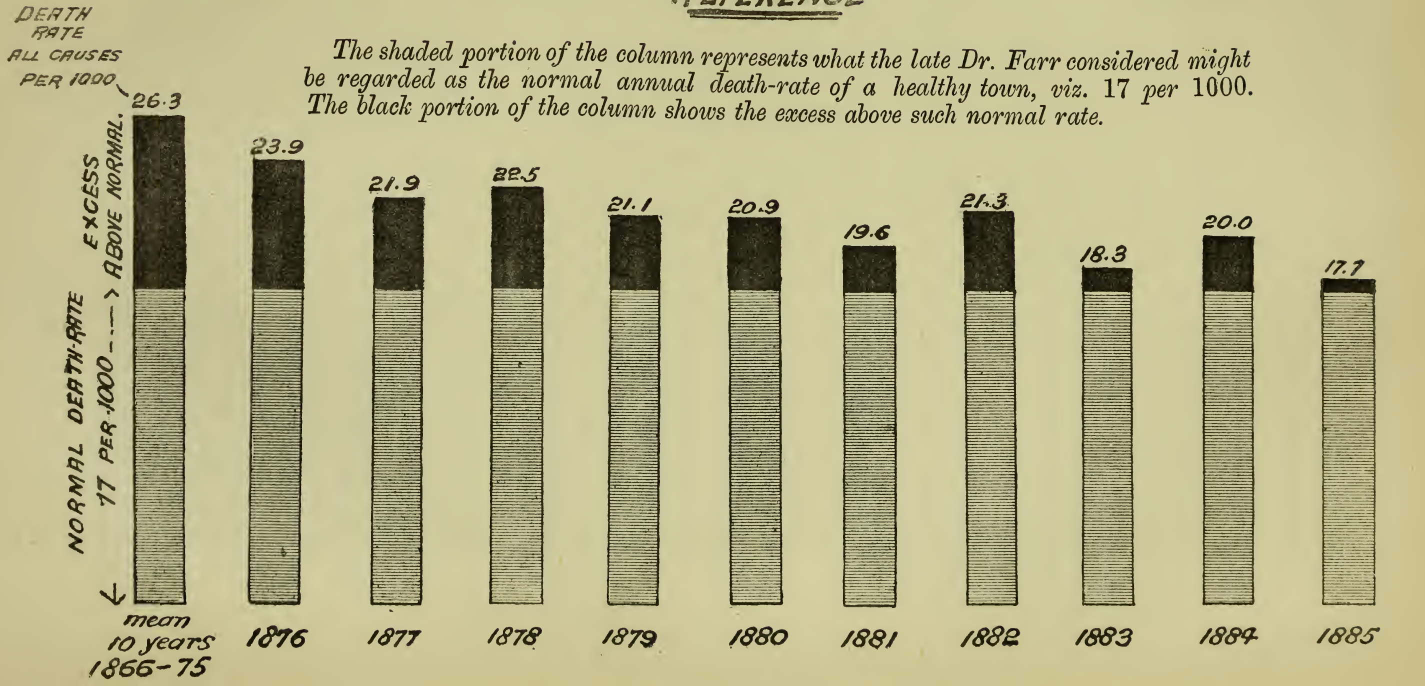
The very favourable state of the public health in Bradford during 1885 will be seen from the following table, which shows that Bradford enjoyed a considerably lower death-rate than any of the

Borough of Bradford

DIAGRAM SHEWING THE DEATH-RATE FOR 20 YEARS 1866-85

REFERENCE

The shaded portion of the column represents what the late Dr. Farr considered might be regarded as the normal annual death-rate of a healthy town, viz. 17 *per* 1000. *The black portion of the column shows the excess above such normal rate.*



seven largest towns in the country both from all causes and zymotic diseases :—

TABLE C.

ANNUAL RATE PER THOUSAND LIVING.

	Births.	Deaths.	
		All Causes.	Principal Zymotic diseases.
Twenty-eight large towns	33·4	20·5	2·7
Bradford	28·98	17·67	1·5
Bristol	31·1	19·6	2·3
London	32·4	19·6	2·3
Liverpool	33·8	23·7	3·6
Manchester	36·2	26·4	5·4
Birmingham	33·7	25·2	2·1
Leeds	34·3	19·9	2·2
Sheffield	34·9	20·6	2·7

Comparing our results with those in Manchester, had the Bradford rate been as high as there we should have had 5715 deaths instead of 3791—that is to say, our low rate has saved 2024 deaths.

Had our fever-rate been as high as in Manchester, we should have had 1159 deaths instead of 322, whereby a saving of 837 deaths from fever has been secured. The favourable contrast of the Bradford figures with those of the average of the twenty-eight large towns in the kingdom, will also be seen from the table.

Gasworks.

The Bradford Gas-Light Company commenced supplying gas from their Mill Street works on the 17th September, 1823.

The Thornton Road works were opened in 1846, and in 1870 their large new works in Valley Road were completed.

By the Bradford Corporation Gas and Improvement Act 1871, the Corporation were empowered to purchase the entire undertaking from the gas company, and the works were handed over to the Corporation in that year for the sum of 210,000*l.*

Since then, the several stations above named have been considerably enlarged and improved, and large new works have been erected at Birkshall in the township of Bowling; the whole of which have cost an additional sum of 330,000*l.*

At the present time the total number of retorts at all the stations is 1520, and the total storage capacity is 7,209,000 cubic feet.

The nett profit derived from the gasworks for the year 1880 was 31,431*l.*, which sum was applied mainly in relieving the rates. The price at this time was 3*s.* per 1000 cubic feet; but on the 1st July 1881, the price was reduced to 2*s.* 6*d.*, consequently the profits for that year fell to 19,245*l.*; in 1882 they amounted to 17,391*l.*; in 1883 they had risen to 22,739*l.*; but in the following year, on account of the great fall in the value of residuals, the profits only reached 17,172*l.*, and for last year 16,506*l.*

Discount is allowed to consumers, whose accounts exceed 1*l.*, varying from 2½ to 12½ per cent. according to the quantity of gas consumed.

In addition the gas committee have, for some years, lighted the public lamps free of charge, besides paying the wages of lamplighters and providing the lamps.

The number of lamps within the borough at the present time is 5985; of this number, 39 are large three-light lamps (Bray's patent), 548 have two lights, and the rest are ordinary lamps with single burner.

Bradford Waterworks.

All the Bradford waterworks are gravitation works. There are no pumping engines or other means employed for raising water from streams or wells. The water is collected at such levels that it can be conveyed directly into the reservoirs for storage and supply. The sources of supply which are available are therefore more limited in extent than would be the case if the water were lifted from some lower level; but on the other hand the water is free from pollution, and is softer and of better quality. The district of supply of the Bradford waterworks is not confined to the borough, but includes thirty-two of the surrounding towns and places, viz.:—Addingham, Adwalton, Apperley, Bingley, Birstal, Burnsall, Calverley, Clayton, Cleckheaton, Denholme, Draughton, Drighlington, Eccleshill, Farsley, Gildersome, Gomersal, Hunsworth, Idle, Liversedge, Morton, North Bierley, Pudsey, Queensbury, Saltaire, Shelf, Shipley, Silsden, Thornton, Tong, Wilsden, Windhill, and Wyke, with an aggregate population at the present time of not less than 364,000. The levels of the district of supply vary greatly, viz. from 200 feet above the sea-level, at Apperley Bridge, to 1200 feet at Queensbury, making a difference of 1000 feet of elevation to be covered by the distribution of water.

The supply is given in two separate services, called the high-level service and the low-level service; the high-level service being again divided and served by separate mains. All the places at a lower elevation than 500 feet above the sea are included in the low-level service, and all the places above that height are included in the high-level service. The pressure of water in some of the distributing mains rises to upwards of 200 lb. on the square inch. The sources of supply for the low-level service lie to the north of Bradford, in the valleys of the rivers Aire and Wharfe.

Various streams, tributaries of these rivers, are taken into the reservoirs and conduits. These streams receive the water from a drainage area of 9770 acres, 7550 acres being in the Wharfe valley and 2220 acres in the Aire valley.

There is no storage reservoir in the valley of the river Aire, so that that part of the gathering ground cannot, at present, be fully utilised. Only the daily flow of the streams can at any time be taken, and none of the winter flow can be collected for summer use. In the valley of the Wharfe there are three storage reservoirs, viz. the Upper Barden, the Lower Barden, and Chelker reservoirs.

The sources of supply for the high-level service lie to the west of Bradford, in the valleys of the Denholme Beck and the river Worth, both tributaries of the river Aire. The principal streams taken are the Stubden Beck, and the Foreside Beck in the Denholme valley, and the Bond Clough, Rag Clough Beck, Greenholes Clough, and others in the valley of the river Worth. The drainage area of these streams is 2700 acres, viz. 900 acres in the Denholme valley, and 1800 acres in the Worth valley. The average rainfall is about 42 inches per annum, and the lowest level at which water is taken for supply is 1030 feet above the sea-level.

Nearly the whole of the gathering grounds from which the water for supply is drawn are high moorlands, above the reach of any pollution from populated districts. They range in elevation from 600 feet to 1475 feet above the level of the sea.

The total acreage of the drainage areas, exclusively appropriated for the supply of the town, is 13,000 acres, viz.:—

	Acres.	
Low Level:		
Wharfe Valley	7550	
Aire Valley	2220	
		9770
High Level:		
Denholme Valley	900	
Worth Valley	1800	
		2700
Old Works:		
Many wells springs		530
Total		13,000

The water collected from these sources is conveyed to the town by means of covered stone conduits and large iron pipes. The length of the conduit from the Heaton Service Reservoir, at Bradford, to the Barden Reservoir is 18 miles, and from the Barden Reservoir to the Sandbed Beck, at Burnsall, the most distant stream taken to the north, 4 miles. The length of the iron main from the Horton Bank Reservoir to the Stubden Reservoir, at Denholme, is 5 miles, and of the conduits, from the Stubden and Thornton Moor reservoirs to the Bond Clough, at Haworth, the most distant stream taken to the west, about 9 miles. The whole of the works so far mentioned are exclusively for collecting and supplying water for the use of the town. Other reservoirs, with separate drainage areas, have been made for compensation water to the various mills and streams which are affected by the taking of the town supply, viz. the Grimwith Reservoir, at Hartlington, for giving compensation water for that which is taken from the streams in the valley of the river Wharfe; the Silsden Reservoir, at Silsden, for the low-level works in the valley of the Aire: the Hewenden Reservoir, at Hewenden, for the old supply of the Many wells springs; the Doe Park Reservoir, at Denholme, for the high-level works in the Denholme valley; and the Leeming and Leeshaw reservoirs, at Oxenhope, for the streams taken in the valley of the river Worth.

The extent, capacity, &c., of the several reservoirs are as follow, viz.:—

SUPPLY RESERVOIRS.

Name of Reservoir.	Capacity in Gallons.	Depth of Water above outlets.	Length of Embankment.	Greatest height of Embankment.	Area of Water when Reservoir full.	Drainage Area, in acres.	Level above the sea.
		Ft.	Yds.	Ft.	Acres.	Acres.	Ft.
	LOW LEVEL.						
Barden, Upper ..	428,819,000	60	524	125	51½	1570	1170
„ Lower ..	483,404,000	60	750	96	56	1930	697
Chelker	228,582,000	37	333	45	57¼	1290	721
„ West ..	———	—	346	—	—	—	—
Heaton (Service) ..	33,891,000	32	366	39	8¼	—	523
	HIGH LEVEL.						
Thornton Moor ..	175,000,000	27	1340	47	46¼	1260	1241
Stubden	93,184,000	53	190	82	11	900	1028
Horton Bank ..	160,000,000	60	530	100	16	—	910
Brayshaw	57,000,000	19	1090	38	13	—	975
Idle Hill	5,500,000	19½	293	23½	1	—	750
	OLD WORKS.						
Chellow Dean, Upper ..	} 45,248,000	42¼	120	55	8	{ Many Wells Spring }	671
„ Lower ..	31,061,000	37½	90	46	5½	„	640
Whetley Hill (Service)	} 4,551,000	16½	—	23	1⅙	—	523

COMPENSATION RESERVOIRS.

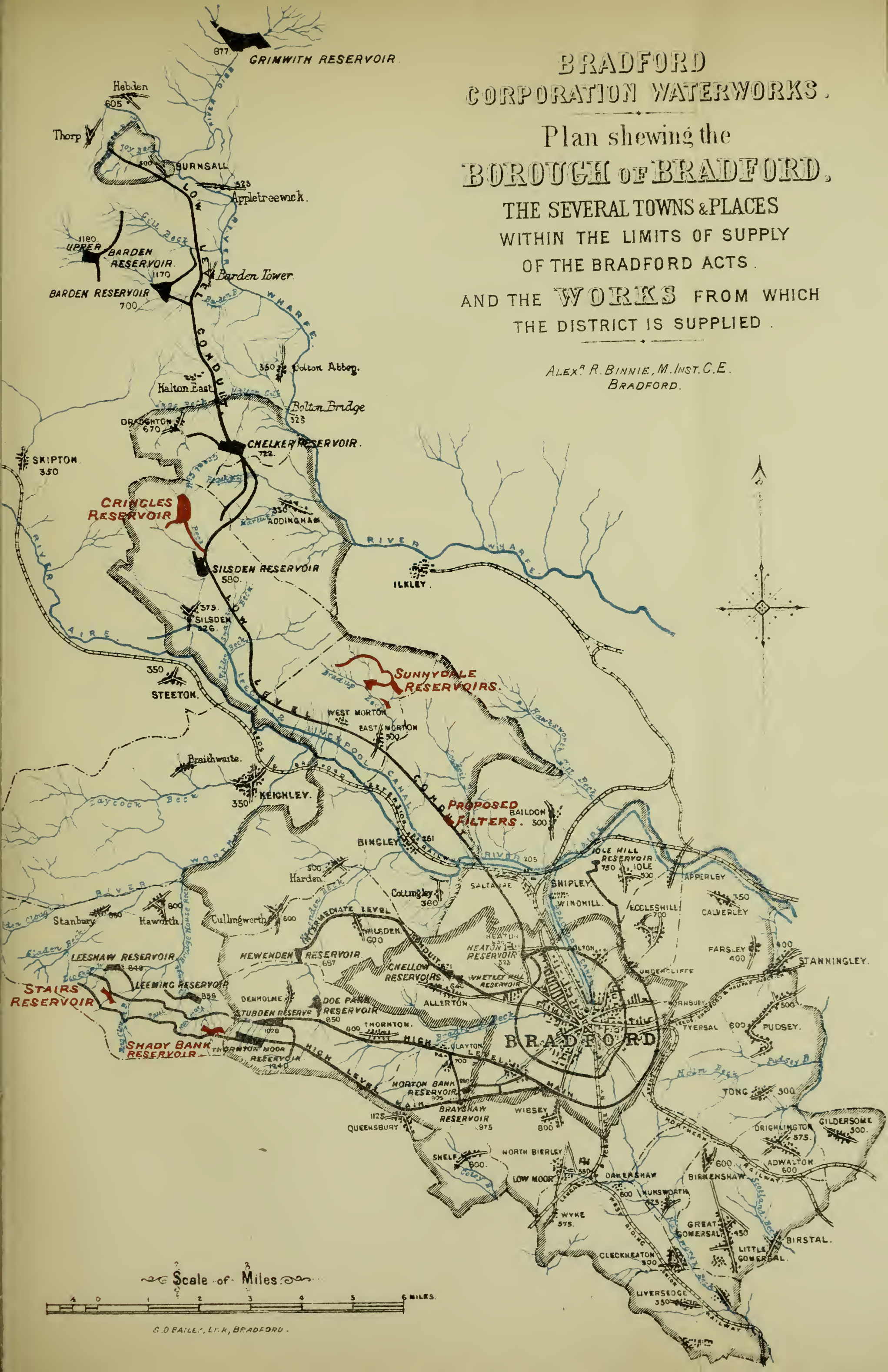
Name of Reservoir.	Capacity in Gallons.	Depth of Water above outlets.	Length of Embankment.	Greatest height of Embankment.	Area of Water when Reservoir full.	Drainage Area, in acres.	Level above the sea.
Grimwith	634,000,000	66	233	83	94	7000	877
Silsden	230,000,000	78	187	94	25	2000	580
Doe Park	110,000,000	52	170	60	20	1000	850
Hewenden	70,000,000	35	230	48	14	1000	687
Leeming	121,474,000	57	247	75	19¼	515	836
Leeshaw	126,562,000	55⅓	367	77½	21¼	505	850

BRADFORD CORPORATION WATERWORKS.

Plan shewing the BOROUGH OF BRADFORD,

THE SEVERAL TOWNS & PLACES
WITHIN THE LIMITS OF SUPPLY
OF THE BRADFORD ACTS.
AND THE WORKS FROM WHICH
THE DISTRICT IS SUPPLIED.

Alexr R. Binnie, M. Inst. C.E.
Bradford.



~ Scale of Miles ~

G. D. BAILEY, LITH, BRADFORD.

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DISCUSSION.

Mr. Cox: There are other things I could mention, but will be content with expressing my obligations to Mr. Binnie, the waterworks engineer, and to Mr. D. Swallow, the gas engineer, for many of the useful items of information I have tried to illustrate to the Members of the Association by means of the paper read.

Mr. A. **Fowler**: I would ask if the annual cost of the sewage works, stated at 3200*l*., included the repayment of any portion of the capital?

Mr. Cox; No, the amount stated was independent of the sinking fund and interest on loans.

Mr. A. R. **Binnie**, Engineer to the Bradford Corporation Waterworks: I am delighted on such occasions as the present, to give what information I can. I hope, too, that if the necessity arise after the meeting, that the members will address me, and I shall be happy to comply with their request for any information relating to the Bradford Waterworks system. From what has been seen to-day at the works you would be led to expect that I should make some remarks on the subject of the purification of water. The question was indeed one of great importance, and for the last two years I have devoted a considerable amount of care to certain experimental trials as to what are the best materials for purifying water. I have used a number of materials—charcoal and iron, in various forms, and sand, and I found that the latter possessed many advantages when compared with the use of more expensive and more difficult materials. And according to Dr. Frankland it possesses this other property, that it would remove germs from the water, the existence of which was so dangerous to life. One thing which had struck me in reading Dr. Frankland's paper was, that however clean water was made, unless every germ was removed there was a prospect that the germ would reappear. The question of germ life is so new to us as engineers, and we know so very little of it, that it is better that we should guard ourselves in making statements or in rushing to conclusions. On Monday I hope to have the pleasure of accompanying some gentlemen present to the large reservoirs belonging to the Corporation. I am sorry I had not the pleasure of meeting the Association some few years ago, when the reservoirs were approaching completion, for at such a time information could be more readily gathered. With regard to concrete, I have had large experience in the construction of reservoirs, and in which the only material used was puddle. The first concrete I put in was the ordinary lias lime concrete, which is as good as most concrete for all practical purposes. Waterworks engineers, however, have come almost entirely to rely upon cement concrete as the material which must replace the old concrete below the ground level. The making of the concrete is, nevertheless, the whole secret. Nearly all the books treating upon concrete have before them concrete as adapted to building purposes, and not concrete as a watertight material. If you deal with concrete as a building material, I advise you to use the hardest concrete you can obtain with the smallest amount of sand, and to put into it the smallest amount of water. When you come to look at concrete from the point of obtaining a watertight material, I think it will be found that this mode of procedure must be very much altered, and that the best stone which can be obtained must be used with a large amount of sand, and an almost superabundant quantity of water. When mixed, the concrete should be in a semi-fluid state. It is almost impossible to specify what should be the necessary amount of sand to use with any particular class of stone. Good material can only be produced after experiments with the particular stone about to be used. I have been speaking of the use of concrete for the lower parts of reservoirs, and I now come to answer the particular question as regards the lining of reservoirs. I have not met with a case where cement concrete had failed. Where you can see such a basis of unyielding rock as has been seen to-day there can be no fear of failure. I should, however, consider the construction of a reservoir or filter-bed on soft soil, with a lining of concrete, with considerable anxiety. My experience of concrete is that it is a very brittle substance, and that it requires a considerable thickness to prevent the pressure acting upon an insufficient basis. At the Barden reservoirs, the trench is 136 feet below the top water level, and the concrete is 6 feet thick. There has not been the slightest suspicion that the water could go through. The concrete trench has been drained through, and the drains are now passing as small an amount of water as they did six months before the completion of the concrete or the filling of the reservoir. I am alluding to the trench, or that part of the reservoir which prevents the percolation of the water under the embankment. The trench is 6 feet in thickness, and as it approaches the ground level it widens out into a large hollow trench some 10 or 12 feet in depth, in which stands the puddle-wall of the embankment. The centre of the embankment is formed of the best puddle procurable—all of it being worked in a pug-mill; it is a well-packed, reliable embankment, and it is to assist in the formation of this that the steam roller has been adopted.

The President said it was his pleasing duty to propose a formal vote of thanks to Mr. Cox for his paper, which was carried unanimously.

Mr. Cox, in reply, thanked the Association for the kindness and attention with which the paper read had been received. He was sorry the time at the disposal of the Members had been so short, and that the programme of the day had not been completed.

Mr. Lobley proposed a vote of thanks to the Mayor and Corporation of Bradford, for the use of the rooms at the Town Hall, for the purposes of the meeting.

Mr. McKie seconded the resolution, which was carried.

Mr. Hooley proposed, and Mr. Spinks seconded the following resolution, which was supported by Mr. Price and Mr. Fowler, and carried unanimously.

(Resolution.) "That in the opinion of this meeting it is desirable "to strengthen the Parliamentary Committee of the Association, "and that the Council of the Association be requested to make "arrangements to protect the interests of the Association in reference "to Bills in which the professional interests of the Members of this "Association will be materially affected."

Mr. Hooley: I wish to draw the attention of this Association to certain Bills now before Parliament which may materially affect Surveyors at present holding appointments under Urban and Rural Sanitary Authorities, as small districts will be absorbed by larger ones, and so the number of appointments open to Members of this Association will be reduced.

I therefore desire, that in the event of the introduction of the County Bill, the Association shall be heard before a Parliamentary Committee to whom the Bill may be referred, with a view to the protection of Surveyors at present holding appointments under such Urban and Rural Sanitary Authorities.

Mr. Spinks, in seconding the resolution, said: There are now before Parliament two Bills materially affecting us, one is a Bill to amend the 150th and 152nd sections of the Public Health Act, 1875, introduced by Mr. Dodds on behalf of the Municipal Corporations Association, and the other a Bill to amend the Highways Act, introduced by Mr. Duckham. With regard to the former measure, I have gone carefully through it and think that it will cause a considerable addition to our work, and leave many open doors for litigation, and it is much to be deplored that the parties who framed the Bill did not consult the Council of this Association. The Public Health Act has now been in existence nearly 40 years, and who, I should like to know, are more conversant with its operation, and more competent to advise on its reconstruction than the Members of this Association? I have searched the digests of the cases that have been before the Courts and find there are no less than 98 of them, all of which do not turn upon points of law, many being on questions of facts which arose in the carrying out of the works by the surveyor, and I repeat, that it is a great pity that the Council was not called into consultation by those who framed the measure. I have myself taken considerable interest in it and have drawn up several amendments and suggestions on points that have arisen during my practice. These I submitted to Mr. Dodds, Mr. A. J. Balfour, the late President of the Local Government Board, and other members of Parliament, one of whom, Mr. Jno. Addison, Q.C., the member for Ashton-under-Lyne, was good enough to discuss with me in detail the Bill and my suggestions thereon, and he promised to bring forward some of them as amendments in Committee; this stage has been postponed, and within the past few days I have heard from Mr. Addison that the Government had decided to adopt some of my suggestions, and the Bill is being reprinted and will shortly be re-issued. I mention this matter because I think it is a great pity we have not had an opportunity of discussing it, and I hope that some arrangement will be made by which we can do so on an early date. I am afraid I have somewhat digressed from the resolution, but I consider the present time is most suitable for discussing the details of the Bills I have named.

The President: The members of the Association have to day had a most interesting meeting. Mr. Cox has read a paper which would occupy two or three hours to discuss fully, and Mr. Binnie has shown the new filter-beds at the waterworks, about which the members would like to hear more. I have had the pleasure of walking over the waterworks with Mr. Binnie, and received from his own lips explanations regarding details which were not apparent at first sight. It is possible that some of the other members may wish to hear some further explanations, but the time at our disposal was very limited, and the business must be crowded into the shortest space. I must, however, say one word in regard to the matter mentioned by Mr. Hooley. It is the earnest desire of the Council of the Association to bring the opinions of the Association into prominence, especially when subjects affecting the interest of its members are before Committees of the House of Commons. The surveyor or engineer to a corporation is not always in touch with the Municipal Corporations Association, and is often not consulted, even with regard to the practical matters, on which, of course, the opinion of the surveyor would be invaluable. If Mr. Hooley or any other member would consider the matter further, and bring it forward in some definite shape at the next annual meeting, I shall be glad to confer with him as to how it should be done. All I can say is, that the proposal has my hearty sympathy, and I will undertake that it is properly represented at the meeting of the Council which will shortly be held. I take it that it is the desire of this influential meeting that something of the kind suggested by the resolution should be taken in hand by the Council. There are other matters connected with the work of the Association on which I would like to speak: one subject especially, which concerns not only ourselves, but the public at large, and the authorities under which we act, and the health and well-being of society in general. I refer to the voluntary examination of members, which was authorised by the Association at the last annual meeting, and which was being brought into satisfactory shape. When this Association was first established it was felt that something was necessary to improve the status of its members, and likewise, if possible, to improve its members, and to prevent improper and incompetent men from obtaining appointments as surveyors to local authorities. It was believed the best way to do this was by instituting a system of voluntary examinations, and if all the members would make some little sacrifice the result would benefit the whole community. The Council has already conveyed an intimation to the members that the first examination will be held next week, and I am happy to say that a large number of candidates had entered the lists. It was proposed to give certificates of competency to those who could prove their efficiency. The nature of the examination would be to ascertain if the candidate was fit and qualified to perform the duties of surveyor or engineer to local authorities, and to give sound advice on subjects which those local authorities required to be advised upon. Unfortunately, in times past a large number of persons had secured positions for which they were in no wise fitted; but it was hoped, by means of these examinations, to prevent such persons in future obtaining engagements for which they were not qualified. I am glad to inform them that members of this association, holding very high positions in large boroughs, and under other important local authorities, and about whose qualifications there could be no question of doubt, had already intimated their intention of submitting themselves for examination. I hope this will be the means of setting a wholesome example to the younger members of the profession who would ultimately take their place, and in the interests of the profession at large, the Council hoped all the younger members of the Association would avail themselves of an early opportunity to present themselves for examination. The days appointed for examinations in future would be advertised in due course in the professional newspapers.

During the day the members, accompanied by Mr. Cox, drove to Gilstead, where the filter-beds in course of construction were inspected. On the return journey the sewage desiccation works at Frizinghall were visited. In the streets a water-cart of special design was inspected, and a sand distributor, both of which, but especially the latter, were highly approved. The members subsequently dined together in the Town Hall, on invitation of the Mayor. In the unavoidable absence of the Mayor, Mr. Vawser, the President, occupied the Chair, and was supported by Mr. Binnie, the Waterworks Engineer, and Mr. Cox, the Borough Surveyor.

Bradford Corporation Waterworks.

On Monday the 12*th April, the members, upon the invitation of Mr. Alex. R. Binnie, F.G.S., Mem. Inst. C.E., Engineer to the Bradford Corporation Waterworks, visited the Corporation Waterworks upon the Barden Beck, near Skipton. The Upper Barden Reservoir was the chief attraction; the great height of its embankment* (125 *feet), the cast-iron valve tower, cast-iron tunnel outlet, and other accessories, were the subject of much interest, heightened by the explanatory details given by Mr. Binnie as each portion of work was in turn examined.*

DISTRICT MEETING AT GREAT YARMOUTH.

June 5, 1886.

Held at the Town Hall, Great Yarmouth.

Mr. J. Gordon, *Vice-President, in the Chair.*

Mr. E. Buckham was unanimously re-elected Honorary Secretary for the Eastern Counties District.

GREAT YARMOUTH, AND SOME OF THE RECENT WORKS OF ITS SANITARY AUTHORITY.

By J. W. COCKRILL, Borough Surveyor of Great Yarmouth.

The Borough in which we are now assembled was incorporated by Charter from King John, in 1208.

The wall surrounding the old town shows some good work in flint, was commenced in 1285 and completed during the reign of Edward III. (1327 to 1377).

Population at the commencement of this century was 16,573; at census of 1881, 46,159, and now is very near 50,000. The death-rate as given by the Registrar-General last year was 17·85.

The acreage is about 3,400 of which 500 acres is Corporation waste and available for building land.

The roads and streets are upwards of 110 miles in length, exclusive of the "Rows," of which there are about eight miles. The

"Rows" form a peculiar feature of the town and accommodate a population of upwards of 13,000.

SEWERS.

There are upwards of fifty miles of sewers in the Borough, and as the work in connection with them forms one of the most important duties which we are called upon to perform, I will describe the work executed to them during the last four years.

The river Yare which divides the Borough into two equal parts as far as area is concerned, forms our main sewer, and in my opinion makes a most efficient one. A strong tidal current exists, with plenty of back-water, by which the sewage is swept out to sea, only returning to the beach at a point beyond the Corporation district.

In 1881 and 1882 complaints were repeatedly made about the stench given off by the surface ventilators to the sewers, and in October, 1882, I was instructed to investigate and report upon the condition of the sewers in the town district, and the necessary work to put them into efficient working order. To carry out these instructions I opened 144 sewers, upwards of 23 miles in length, at points not more than 100 yards apart, and the form of procedure and the shape the work took can be best seen by the tabulated statement attached, forming Appendix "A," which gives the condition of what I consider the best and the worst sewer in the district under consideration.

The defects discovered in the sewers were in a large number of cases entirely attributable to the utter disregard with which private and even Corporation connections had been made with them. The worst case, and one very frequently met with, is sketched in Fig. I.; a fair connection would be that sketched in Fig. II. A large quantity of brick sewers existed within the walls, sections of some of which are given in Figs. III., IV., V. and VI.; these were several centuries old, the bricks were thoroughly rotten and rat eaten, and many of them so repaired, altered and cut about, that there were not 10 yards in one length in which the sewer remained of its original section. In two cases the sewers had been cut off from the outlet through which they had originally drained and were connected with another sewer at their upper ends, thus involving a deposit of 15 or 18 inches of sewage in about 100 yards in each case. You will not wonder that about 12 months previous to the discovery being made three deaths from diphtheria had taken place in one house draining into one of these sewers.

I advised the Sanitary Authority to take up and relay all the pipe sewers in which any defects had been discovered, re-making private connections with the same with proper junctions, and to take up all the old brick sewers and replace them with glazed pipe sewers. That the district drained by the sewer No. 2 in Appendix should be raised by a gas-engine and centrifugal pump, similar to one I had already fixed in a low-lying district within the Borough on the other side of the river and which had worked well. I advised that full means of flushing on some automatic system should be adopted wherever possible, and that a movable flushing-tank be constructed of 3,000 gallons capacity, the drawing of which lies on the table before you. That the sewers should be thoroughly ventilated by pipes, with a sufficient number of surface gratings to provide fresh air, and that the sewers should be divided into lengths by light galvanized iron flaps, to prevent the uprush of sewer air from the low levels into the upper reaches of the sewers; my estimate for this work was 8,000*l.* I also advised, connections should be only made by Corporation men, and that only with proper junctions for both brick and pipe sewers, and I invented (although I afterwards found out that a similar block was in use at Leeds), the junction block for pipe sewers now before you. I have found that in making connections, if you insist on taking out a pipe and inserting a junction, that it is next to impossible to get your sewer laid correctly again, and I claim for this block that a connection with ordinary care can be made quite equal to that made with the junction pipe in one piece.

The report before referred to, in the main was adopted, and after more than two years' trial the work done gives thorough satisfaction; the estimates were not exceeded, and for the sum of 8,000*l.* about six miles of new pipe sewer were laid and seven miles of pipe sewers relaid, involving about one-third new materials; about 3,000 house and other connections were re-made; 40 cast-iron ventilating pipes, 6 inches by 9 inches and 6 inches by 6 inches were erected against houses, three wrought-iron shafts to stand alone and two brick shafts (four brick shafts had been previously erected) and six flushing tanks of 3,000 gallons capacity, with automatic siphons, were put at the heads of sewers where they would do most work.

SEA WATER WORKS.

The cost of water to supply these flushing tanks, and the large movable tank, led to discussion as to whether it would not be advisable to provide our own supply for sewer flushing and street watering; of course, opposition was raised to this; scientific evidence was obtained to prove that sea water would be both injurious to roads and health, and under my advice the opinion of H. P. Boulnois, Esq., of Portsmouth, was obtained on this subject, and at the enquiry held before the Inspector of the Local Government Board, he completely (or at least to the satisfaction of the inspector) demonstrated that all the evil charges made against it were untrue, and that much good might be expected both on roads and in sewers by its use.

I had had previous experience in road-watering with it, found that it was much more efficient in laying dust, and that roads in the summer time were less liable to break up than where fresh water was used, but advised that one section of the town should be watered for a whole season; this was done, a large expense was saved in quantity of water used, and also in gravel which it had been necessary on previous occasions to use for patching.

The Council had, during the year previous to this matter being brought on, used about 10,000,000 gallons of the company's water to flush sewers and water the roads in the district which I proposed should be served with sea water; this 10,000,000 gallons had cost 552*l.* 0*s.* 6*d.*, while the average cost of the water for seven years, in which little or no flushing had been done, came to 404*l.* 6*s.* 7*d.*, and I estimated that to supply the flushing necessary to keep our sewers clean would involve an outlay of at least 700*l.* per annum, and for this we should receive about 14,000,000 gallons only.

The scheme I prepared involved fixing an "Otto" gas engine of 8 horse-power (making the third I have now fixed for this Council, the previous ones working admirably), with pump, the erection of a tower, and cast-iron tank to hold 22,000 gallons, 6 miles of distributing pipes of 8in., 7in., 6in., 5in., 4in. and 3in. internal diameter, with 40 valves for flushing, and 40 hydrants for street watering; six flushing tanks of 2,000 to 3,000 gallons capacity are also included (making 12 I have now at work), and, much to my surprise, my estimate only came out at 4,500*l.*, and Messrs. H. F. Snow and Co., of London, are now at work upon the scheme, and within a month of completion, the contract price being 3,987*l.*, while works not included in this contract, may, perhaps, amount to about 200*l.*

These figures give a clear gain to the Corporation, as may be seen below:—

	£
Interest and repayment of loan on 4500*l.*, per annum	270
Working expenses, depreciation and small additions, per annum	140
Total annual cost	£410

For this sum the plant I have erected will raise in 120 days, of ten hours each, 30,000,000 gallons, of which about 5,000,000 gallons will go on to the streets, while the remaining 25,000,000 gallons will go into the sewers, and more can be raised at less than 1½*d.* per 1,000 gallons, as less water is used for street watering; a considerable save will also be made in horse hire; this I estimate at about 80*l.* per annum.

CONCRETE FOOTWAYS.

In the Borough there are nearly 15 miles of footway laid with concrete, in a similar manner to that now being put down and described below. Some of this has had heavy traffic for 15 years, and now shows no sign of wear, and will, I have no doubt, under fair treatment, last at least half a century longer, and, in my opinion, is the cheapest and most durable footway which can possibly be formed.

The works now in progress have been undertaken by Messrs. M. C. Duffy and Son, of London and Yarmouth, and include about 17,000 yards super of footway, 2½ inches thick, at 1*s.* 9*d.* per yard super, rather more than 3 miles of kerbing at 1*s.* per yard, and a large quantity of granite crossings.

The following are a few of the rules which experience has taught me should be observed.

Concrete must not be laid in frosty weather, and I have none laid from the middle of October to the end of March.

It is also better to avoid extreme heat, as the sun takes the moisture out of the upper face before the cement has time to set. What concrete work I have done in hot weather is always well watered. If this is not sufficient, it should be kept covered with mats. It is also advisable that the ground should be well wetted before it is laid.

The expansion in hot weather is counteracted by the insertion of wood splines, placed from 5 feet to 6 feet apart. These are of the full depth of the concrete, and if at any time a piece of pavement is found to be lifting with the heat, at night, as soon as the temperature begins to lower, if a spline is taken out in every 100 feet of the footway, it will resume its proper position.

An objection to concrete paving, as laid *en masse* by us, is the difficulty of laying drains, water, and gas pipes through same, without cutting it up. Our water and gas companies find it possible to get under paths 7 feet, 8 feet and 9 feet wide, without breaking them up.

The paving now being laid is 2½ ins. thick; the lower 1¾ ins. thick, composed of four parts beach shingle, screened through a half-inch sieve, to one part Portland cement; the top, ¾ inch thickness, is composed of two parts beach shingle screened through a sieve of ¼ inch mesh, and one part Portland cement.

The kerb is 6 inches by 9 inches, and mixed in the same proportions as the paving.

In practice, I find that however carefully concrete is laid, or how good the proportions, it will not stand vehicular traffic, and that is the reason for the large quantity of granite crossings included in this present contract.

In selecting the materials to form the base of the concrete, I have found that no other class of materials wear as well as beach shingle. We have, in this town, some paths formed with crushed granite as the base, and the same proportions of cement, laid in the same line and at the same time as concrete composed of shingle. In one path the granite has worn so as to form a hollow half-an-inch in depth. In another case, it is broken through in so many places that it is intended to take it up and relay it in this present contract; while those paths laid with shingle as a base show no signs of wear. Sand should be carefully screened from the shingle, although it makes a better looking concrete. Under traffic it wears very rapidly.

SLAUGHTER HOUSES.

This Sanitary Authority has also had under discussion the desirability of erecting public slaughter-houses, and for this purpose I was instructed to obtain information on this subject and prepare a report. The information I obtained is tabulated, copies of which lie on the table for use of members; summarised, the information is as follows:—63 towns were asked for information; replies were received from 52; of these 30 had no public abattoir, and in those with abattoirs, most had separate slaughter houses, and lairage for each butcher. Compulsory powers to close all private slaughter houses had been obtained by several towns. In 10 towns the abattoirs were found to be a paying concern, while in 5 other towns they were found not to pay their way. About 15 other towns were considering, or had considered the question.

This matter has been before the Committee several times, but no orders have yet been given. The plans and report I have prepared on this subject are on the table for the information of members.

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THE SEWERAGE, SURFACE DRAINAGE, SEWAGE DISPOSAL, AND HOUSE DRAINAGE OF THE MARKET HARBOROUGH, GREAT AND LITTLE BOWDEN LOCAL BOARD DISTRICT.

By E. G. MAWBEY, Assoc. M. Inst. C.E., Borough and Water Engineer, and Surveyor, King's Lynn.

In the designing and supervision of these works, Mr. J. B. Everard, Assoc. M. Inst. C.E., of Leicester, was the consulting engineer, and the author was the acting engineer.

Mr. George Stevenson, of Eckington, Chesterfield, was the contractor. Mr. H. G. Coales, then the author's pupil, rendered valuable assistance in the preparation of the drawings, and in the supervision of the works.

The area of the district is 4416 acres. Length of roads and streets about 20 miles. Population 5500. Number of houses 1190. Rate of population to inhabited houses, 4·62; ditto per acre in Market Harborough town, 127. Rateable value about 37,000*l.*

In March 1880 the author found the district in a most insanitary state, and nothing in the way of plans, but very crude and unreliable sketches of the streets and old sewers.

A survey of the town and district was at once undertaken, and almost simultaneously the designing of the sewerage, &c.

Sewerage.

Market Harborough and Little Bowden are for the most part situate at the lowest level in the valley of the river Welland, which for several miles is very flat; it was therefore somewhat difficult to design an efficient system of sewers at a sufficient depth to drain the basements, and to deliver the sewage without pumping on to the surface of suitable land. This however has, with the aid of flushing arrangements, been accomplished.

The sewers are laid deep enough to drain the cellars of houses, being an average depth of about 9 feet, but varying considerably according to circumstances, and in some cases are fifteen to eighteen feet deep.

The total length of the new sewers for sewage proper is 9¼ miles.

Every old sewer is for carrying sewage proper abandoned.

The sewerage is as far as practicable carried out on the separate system, the surface drainage being excluded, excepting the rainfall from back roofs and yards and such of the street surface drainage as is required for periodical flushing. The latter can be received or rejected at pleasure.

By this arrangement, where adopted, the first washing of streets is discharged into the sewers.

Much of the rain water from the house roofs is however collected in underground tanks and used for domestic washing.

The 21-inch outfall sewer from Market Harborough and Little Bowden is, when running full, capable of discharging one-half of 5 cubic feet of sewage per head per twenty-four hours, in six hours, and also a rainfall of nearly ¼ inch per hour from back yards and back roofs, from double the present population, allowing 20 square yards area per head, and assuming that (after allowing for that portion which flows over the surface into the streets, and that received into private rain-water tanks, &c.) only half the rainfall on back yards and roofs enters the private drains.

The 24-inch outfall sewer below Great Bowden, for the whole district, will discharge more than these proportions.

The system of straight lines and uniform gradients between manholes and lampholes is adhered to.

The sewers are all of glazed stoneware socketed pipes from 9-inch to 24-inch diameter.

The thicknesses of the pipes are :—

Diameter	9 in.	12 in.	15 in.	18 in.	21 in.	24 in.
Thickness	⅞ in.	1 in.	1¼ in.	1½ in.	2 in.	2⅜ in.

Length of pipes, 9 inches to 21 inches = 2 feet 6 inches; 24 inches = 3 feet.

The pipes were jointed by first laying on a fillet of cement all round the shoulder in the socket before lowering into the trench; when the pipe was passed well up to the shoulder, a complete ring of tarred hempen-spun gaskin was caulked into the socket; the socket was then filled up with cement, caulked with a proper tool, and a fillet of cement worked round the outer edge of the pipe.

The jointing material was one part of Portland cement to one part of washed sand.

The joints of the 18-inch, 21-inch, and 24-inch pipes were pointed up solid inside.

In wet ground the author's patent jointed pipes were used.

In some cases in running sand or other unstable ground, and where much water was met with, the sewers were surrounded with Portland cement concrete, and the *modus operandi* proved very successful in making the sewers absolutely watertight, thus preventing the influx of subsoil water.

The water was kept pumped down below the trench bottom until the concrete was set.

A 9-inch bed of concrete with the surface formed to the sewer gradient was first put in, on which the pipes were laid. The trench was then filled in up to about two-thirds of the height of the pipes with fine semi-liquid concrete of cement and crushed granite well worked round the joints, and the upper portion of the joints carefully caulked with cement. The trench was then filled up with ordinary concrete to 6 inches above the top of the pipes.

Sub-drains are laid where necessary, leading to sumpholes at the sides of the trenches from which the water was pumped and kept down day and night until the concrete or jointing materials were set.

It frequently happened that the sewers were laid in the blue lias clay just below a bed of drift gravel, yielding a considerable quantity of water which flowed into the trench and could not drain from the joint-holes through the impervious clay into the sumps (as in permeable soils) without a sub-drain.

The manholes, lampholes, and flushing tanks are built with selected common bricks in Portland cement, in the proportions of one part cement to two parts of sand. The inverts are formed with purpose-made radiating best Staffordshire blue bricks in cement.

The tongues at the junctions are formed with neatly tooled blocks of hard Freebirch stone.

The outfall sewer from the disposal area to the point where the Great Bowden main sewer comes in, a length of 912 yards, is 24 inches diameter and has a gradient of 1 in 975.

From this junction to the junction with the Little Bowden main sewer, a length of 2115 yards, the sewer is 21 inches in diameter and the gradient still 1 in 975.

From the Little Bowden junction to Market Harborough, a length of 527 yards, the diameter is 18 inches and the gradient 1 in 759.

The main trunk sewers in Little Bowden are 15 inches and 12 inches diameter.

There are 171 yards of 15-inch sewer and 454 yards of 12-inch sewer with gradients of 1 in 550, and 326 yards of 9-inch sewer with a gradient of 1 in 350.

There are also several lengths of 9-inch sewers with gradients of 1 in 300.

These gradients are certainly flat, but could not be improved without having a pumping scheme, and although the whole of the house drainage is connected, which is a water-closet system throughout, and at present almost entirely depending upon hand flushing, there being no water supply but from shallow wells, these sewers, after working over three years, are free from deposit.

There are, however, ample means of flushing the sewers.

On the outfall sewer, 3554 yards in length, there are three flushing tanks, having a discharging capacity of 2500 gallons each.

Two of these tanks are supplied by small tributaries of the Welland, each being intercepted at a high level by a small brick chamber, from which is laid a 2-inch cast-iron pipe with a sluice valve for adjustment at the tank.

The third tank at the head of the outfall sewer is supplied from the main surface-water sewer of the town, through which there is always a sufficient flow.

Another line of sewer is flushed by one of Mr. Roger Field's annular siphons, supplied by Messrs. Bower, Scott, and Read.

The discharge of each flush from this siphon is 1500 gallons, the length of sewer flushed 723 yards, the diameters 15-inch and 12-inch, and the gradients varying from 1 in 500 to 1 in 34.

This siphon tank is supplied, through a 1½-inch galvanised iron pipe, from a large pond, and it works admirably.

At the head of each sewer where a supply of water could be obtained from dykes or surface drainage, and in several other places, circular flushing tanks are constructed, giving a flush of about 750 gallons, discharged by a Bailey Denton's flushing penstock, which after several turns may be quickly lifted to give at once the full flow.

In the villages the sewers are also flushed from ponds and streams by hand flushing valves fixed in small brick chambers.

On the outlet of about half the number of manholes, a Baldwin Latham's stoneware flushing block, with ground face for shuttle-board, is fixed for damming up the sewage when necessary for flushing and inspection, and provided with a safety discharge pipe.

One of these flushing blocks is fixed in the manhole at the head of every sewer; and for short branch sewers where there is no tank, the manhole is charged with a street watering van.

A man is employed for flushing, whose first duty is to keep the sewers clean.

The sewers are ventilated throughout by street surface gratings. Each ventilator has 81 square inches unobstructed area of openings, and their average apart is 70 yards.

At every ramp or jump of a sewer, and wherever there was sufficient fall, a Baldwin Latham's balance valve was fixed in the manhole, to prevent the onward passage of sewer air, and these were adjusted to suit the gradients and flow of sewage.

A junction for private drainage was put in, opposite every property, and wherever likely to be required in future for new buildings.

The distance of each junction from the centre of the last manhole or lamphole was measured, and sketched and figured in a surveying field-book.

A mark was put on the building opposite, and where there was no building a stake was driven in.

The sewers and junctions were drawn on plans to the scale of 44 feet to an inch.

In executing the house drains, there was no case where the junction was not readily found, or where a junction had to be inserted.

SURFACE DRAINAGE.

All the old sewers which are of any service are utilised for surface drainage, and where necessary are supplemented by new sewers and street gullies; outfalls being provided into the river at the nearest available points.

These sewers provide for carrying off a rainfall of a quarter of an inch per hour, assuming that 75 per cent. of the fall will be discharged from the town portions of the district, 50 per cent. from steep agricultural land with fairly drained clay subsoil, 40 per cent. from flat agricultural clay lands, and 30 per cent. from flat agricultural land with a porous subsoil.

The new works carried out consist of 1700 lineal yards of 9-inch to 24-inch stoneware pipe sewers, 100 lineal yards of part 5 feet by 3 feet 3 inches elliptical and part 42 inches circular brick sewers, 60 18-inch Alexandra stoneware street gullies, and 750 lineal yards deepening and widening open water-courses through fields for the drainage of agricultural land lying mostly above the town, which was necessary on account of the original water-courses having been from time to time so obstructed and diverted by building and other operations that the water from this source has of late years during heavy rains flowed into the heart of the town, contributing largely to the disastrous floods for which Market Harborough is so noted.

The low-lying portions of this district (the Welland Valley), in addition to the rainfall within the watershed of the Local Board District, is subject to flooding from the rainfall over about 26 square miles of fairly drained land with steep slopes overlying the almost impervious blue lias clay drained by the river Welland and the Little Bowden Brook; and as the farthest reach of the catchment basin is within six miles of the town, the floods come down very rapidly.

The width of the river has been so seriously diminished by the encroachments of the riparian owners, that it is now altogether inadequate.

In July 1880 the flood rose to 6 feet 6 inches above the street surface in the market-place, when the extent of the damage exceeded the amount needed to carry out works which would almost entirely prevent floods in future.

A great number of houses were flooded, the contents of privy-pits and ashpits deposited on the walls, &c., inside the houses, and the wells polluted, and the cellars heavily charged with offensive matter.

This was, however, the largest flood on record, and was the result of a rainfall of about 4½ inches in forty-eight hours, and of 8½ inches (including the 4½ inches) in the four weeks preceding the flood.

On the 5th and 8th of October in the same year, many houses were flooded and much damage done. On the 5th the rainfall was 2 inches in fourteen hours, and on the 8th, 1½ inches in ten hours.

The author in the same year prepared two Floods Prevention Schemes.

1. To deepen, widen, and embank the river all through the district, to cut off from the river the small drain connections, and to provide the main surface-drainage outfalls with flap valves and penstocks at an estimated cost of 5000*l.*

2. In lieu of the river scheme, to construct large storm-water sewers, to carry off the flood water to an outfall in the river at a point below the populated portion of the district, estimated to cost also about 5000*l.*

To carry out No. 1 scheme compulsorily, a local Act of Parliament was required.

No. 2 scheme might have been carried out, with the sanction of the Local Government Board, as sewerage under the Public Health Act 1875.

The Local Board were afraid to run the risk of the expense of the probable opposition to a Floods Prevention Bill, and at a Local Government Board inquiry consulted Major Tulloch, R.E., as to the possibility of carrying out the river scheme by agreement with the riparian owners.

Major Tulloch stated that a committee of the Board might be formed to ascertain if possible what compensation the riparian owners would require, but that he was afraid they would not succeed, as some of the owners when the time came would probably not agree to reasonable terms, if any, and therefore advised that if they decided not to apply for an Act of Parliament, the most successful course would probably be to apply to the Local Government Board for power to carry out the storm-water sewer scheme.

After a most spirited and persevering attempt to effect the necessary arrangements, although all the owners but two consented to favourable terms and the principal sufferers from floods offered handsome subscriptions, the result was a complete failure.

No. 2 scheme would have effected considerable relief in great floods, and would have entirely prevented ordinary ones; but as No. 1 scheme was far superior to it, and at no greater cost, it was decided to postpone the further consideration of the question, in hopes of the adoption of legislative measures giving them the necessary jurisdiction over the river.

This is one of the many low-lying districts where in wet seasons a great number of helpless people are compelled to endure the many ills attending the inundation of dwelling-houses, and it is to be hoped that ere long a Rivers Conservancy and Floods Prevention Bill will be passed, which will considerably facilitate the carrying out of the great sanitary improvements so much needed in many parts of the country.

SEWAGE DISPOSAL.

The system adopted is intermittent land filtration.

The disposal area, 12 acres in extent, is situate by the side of the river Welland, about two miles from Market Harborough.

The river has been widened for a length of about 800 yards (to work into the proposed Floods Prevention Scheme), and the soil used in embanking around the land, &c.

A macadamised cart-road is formed on the embankment along the river side.

The subsoil is of a loose and friable loamy nature.

The area actually cultivated, exclusive of that taken for embankments, roads, and barrow paths, is 9 acres 1 rood, being one acre to 594 people, which is not sufficient, and the Local Board were advised to purchase more in the first instance, and to eventually procure for broad irrigation another piece of land situate close by, which is of a sandy nature and at a suitable level, and which will shortly become available.

Being originally pasture land, the turf was pared and burnt, and the ashes spread uniformly over the surface.

The whole area to be cultivated was "double-dug," two spits 16 inches deep, and well broken up; the parts which had to be raised were dug before filling up, and the high parts reduced before being dug.

The surface being flat, not more than about a foot had to be excavated on the highest parts to bring each plot to the required levels.

The land is laid out in beds about one acre each, divided by barrow paths raised about 9 inches above the surface.

The barrow paths are covered with burnt clay ballast 4 inches thick.

The beds for root crops are set out in ridge and furrow. The ridges for planting are 4 feet 6 inches wide, and the furrows for sewage 12 inches wide and about 4 inches deep.

The furrows are so arranged that the sewage can be discharged over the whole or one-quarter of each bed separately.

To prevent the sewage flowing over and percolating too direct into the sub-drains, the furrows are cut in the same direction as the drains, and over each drain the ridge or land is 10 feet wide.

Where earth sewage carriers cross the drains, stoneware half pipes are laid, and whole pipes are laid under the barrow paths.

The effluent drains are of glazed socketed earthenware pipes laid with open joints at the greatest available depths, which vary from 4 feet 6 inches to 5 feet 6 inches.

The main drain down the centre of the land is 15 inches diameter at the outfall end, diminishing to 12 inches, 9 inches, and 6 inches at the upper end.

The short branch drains are 4 inches diameter and 40 feet apart, excepting under the osier beds, where they are 20 feet apart.

Small inspection and ventilating shafts are constructed where necessary at the junctions of the sub-drains.

A flap valve and penstock are fixed on the effluent drain at the outfall for protection during floods.

At the outfall of the main sewer there is a "storm overflow sewer" leading from a manhole to the river.

A movable overflow weir penstock is fixed in the manhole, which can be adjusted to allow all or any quantity of the sewage and flood water to flow direct into the river during storms.

In the same manhole leading on to the disposal area is an ordinary penstock, which can be set to admit only the normal flow of sewage, and during floods when the effluent outfall is closed to divert the whole discharge through the storm overflow sewer to the river.

There is a small screen chamber, but no settling tanks.

The sewage is discharged under pressure on to the highest beds at the upper end from distributing chambers on a 21-inch glazed stoneware pipe delivery main, laid with its invert about 2 feet 6 inches below the surface of the beds, and on the lower beds from an open cement concrete conduit 18 inches wide and varying from 18 inches to 2 feet 4 inches deep.

Several beds are flooded by damming-up the sewage in this conduit, and discharging it by light wrought-iron hand sluices fixed in the side of the conduit.

The low level beds being below the invert of the conduit, afford a free outfall on to the surface of the land.

The land before mentioned as being required for broad irrigation is all well below the invert of this conduit.

A small building of two rooms, one for men's mess-room and tools, and the other for seeds, &c., is built in connection with the screen chamber.

An approach road about 100 yards long direct from the highway has been made, and a wrought-iron lattice-girder bridge erected over the river.

The first crops in 1883 were potatoes, 1a. 2r. 6p.; mangold-wurtzel, 2a. 3r. 27p.; Italian rye grass, 2a. 3r. 26p.; osiers 1a. 2r. 36p.

There was a loss the first year, but the accounts for last year show, I believe, no loss on the working and crops, but reckoning nothing for rent and interest or outlay.

The land and working is in the hands of the Local Board.

The effluent during the first year was quite satisfactory, but, as was anticipated, it recently shows that more land is required, and that more attention should be paid to the proper filtering of the sewage than to the crops.

HOUSE DRAINAGE.

The contractors when tendering for the sewerage were required to price in a schedule for new private drainage, in cases where the owners might make default, and for connecting efficient house drains with the new sewers, with a proviso that the Board were not to be "bound" to employ the contractor for such work.

The author drew up regulations pursuant to Section 21 of the Public Health Act 1875, which after some slight alterations were adopted by the Local Board.

The question then arose as to what would be considered a drain "sufficient for effectual drainage" within the meaning of Section 23 of the Public Health Act 1875.

This was an important matter, as it was pretty well known that most of the house drains in the district were either of common red land drain pipes or defective square brick drains, and upon the issue depended whether the district was to be provided with an entirely new system of house drains, or whether after having expended so much money for a new system of sewers, &c., the old house drains, the most dangerous nuisances, were to remain and be connected with the new sewers.

The Board were advised that wherever a drain, whatever its construction or condition, was carrying off the sewage so as not to be a nuisance, manifestly injurious to health, it was sufficient for effectual drainage within the meaning of the Act.

The author advised that for effectual drainage, a drain should at least be of glazed stoneware pipes jointed practically watertight, and on being put to the vote this definition was adopted by the Local Board.

A member of the Local Board appealed to the Local Government Board against the author's interpretation of the words "sufficient for effectual drainage," to which the Board replied, "It appears to the Board that unless a drain is watertight it cannot be considered sufficient for effectual drainage;" and further, in reply to the question as to the material of which the drain should be constructed, the Local Government Board stated that they had no authority to decide the question, and were of course unable to say what view a "Court of Summary Jurisdiction" might take of it, but they were advised that an engineer or architect of standing and reputation would not consider a drain "sufficient for effectual house drainage" unless it were constructed of glazed earthenware pipes or of some other material, for instance, iron pipes equally strong and watertight.

The author strongly urged the Local Board to do all in their power to induce the owners to allow the Board through their contractor to execute the drainage for them, pointing out the advantages of the very reasonable schedule of prices before mentioned, and of their being relieved from trouble and responsibility.

When the new sewerage was sufficiently advanced, the Local Board issued a circular to every owner in the district, asking whether they preferred to execute their private drains to connect with the new sewers themselves, or that the Board should do the work and charge them with the cost. A brief printed form of undertaking, to be filled up in reply, accompanied the circular.

Nearly half the owners at once agreed for the Board to do the work, and subsequently most of the remaining owners also agreed.

The author, however, took considerable pains to induce many doubtful ones to consent, and the contractor rendered valuable assistance in canvassing for the work, but wisely advised the owners to give him the work "through" the Local Board.

On receipt of the "consent" form, in order to avoid failure through irregularity, the clerk served the usual formal notice on the owners under Section 23, to do the work themselves in accordance with the regulations within twenty-one days, accompanied by the explanatory memorandum, "This notice is sent to comply with the Act of Parliament, and it is intended to carry out the arrangement (contained in the circular) to which you have assented, viz. that the Board should make your private drain connections and charge you with the cost."

The regulations of the Board required that before commencing new drainage, a block plan showing the proposed drains and "mode of ventilation" should be deposited.

The Local Board entered into an agreement with their sewerage contractor to execute this work, also an agreement to employ the author (then acting as their surveyor and engineer for the sewerage works, &c.) to prepare the necessary plans and to superintend the work, and to pay him an extra salary for the supervision, and a fee for each plan according to the cost of the drainage of the respective properties.

The extra salary for the supervision was paid out of the "General District Rate," and in each case the fee for the plan was charged to the owner.

When the twenty-one days of the respective notices had expired, the contractor on a certain day in each week dug test holes down to the existing drains of several properties, and the author, accompanied by an assistant, examined the drains and noted the nature and condition of each, and made a sketch of the positions of the drains and test holes, on a tracing of the block plan of each property. At the same time a careful inspection of the property was made and notes taken for the necessary new drainage, &c.

Block plans showing the proposed new drainage, &c., were then prepared and submitted, together with the report on the old drains, to the sewerage committee, who met once a week, and on receiving their approval the work was at once proceeded with by the contractor.

In all cases (if desired) the plans were previously submitted to the owners, and on completion tracings showing all the drains, &c., were supplied to them for future reference.

The house drains when executed were drawn on the sewerage plans of the district.

One member of the Board strongly opposed the enforcing of providing plans for house drainage, but the clerk advised that they were as necessary for ensuring the proper carrying out of the drainage to old houses as for drainage to new houses, and the owners were therefore liable for the cost of preparing them as a part of the cost of executing the work.

The owners have, however, paid for the plans, and many were glad to get them for the small charge made, whilst many others raised objections.

The old drains on every property were examined and the adopted definition of an efficient drain acted upon; as was anticipated, very few efficient drains were met with.

A description of the old drains and their effect on the drinking water will be found in the author's paper on "Domestic Water Supply from Shallow Wells," read at Colchester in 1884.

The regulations adopted embodied the provisions of the Model Bye-laws of the Local Government Board as to drainage, including the mode of ventilation.

Every drain was provided with a ventilating trap with air inlet and dirt-box, and a 4-inch cast-iron extracting pipe.

All waste-pipes were disconnected, and drains under houses surrounded with Portland cement concrete.

As every sewer in the district was new, and as, under the resolution passed, nearly every property would require new drains, the author was of opinion that if a 4-inch extracting shaft were fixed where practicable, at the head of every drain, and the best known means of disconnection with the interior of houses were adopted, all sewage inlets properly trapped, &c., there would then be no more danger in ventilating the sewers through the drains (the pipe outlets being judiciously placed above the house-tops) than at the street surface, or by sewer ventilating shafts fixed on houses, as recently practised, and that there would probably be less offensive emanations from the street surface ventilators.

He therefore recommended that no disconnecting trap be placed on the drain leading to the sewer, as was the case in Mr. Gordon's work at Frankfort-on-the-Maine.

The author has found that where a very good fall is not available, where heavy detritus gets in, or where there is no public water supply, these traps frequently become choked, drained cellars are flooded, and the decomposed sewage causes a nuisance at the air inlet.

Many complaints have in such cases been made against them in the district. There would, however, probably be fewer cases of failure if there were a plentiful public supply of water to every house.

The author must, however, admit that he has found a great number of them under "favourable conditions" to work admirably; but he is of opinion that unless they are very shallow they should if used be fixed in a chamber large enough for a man to enter. This condition cannot, however, at present be enforced.

Mr. Jos. Gordon, M. Inst. C.E., has invented a ventilating trap for this purpose, which certainly possesses very special advantages.

The carrying out of this work with the indefinite power provided in the Public Health Act 1875 has proved a very onerous undertaking, for at present very considerable difference of opinion and misunderstanding exists as to the nature and extent of the regulations which, under Section 21 of the Public Health Act 1875, local authorities are empowered to make, for the drainage of old and existing properties, causing much dispute and obstruction, particularly as to whether the depositing of plans may be enforced, whether the drains must be ventilated, surrounded with concrete under houses, provided with means of flushing, disconnection of waste-pipes, alteration of unventilated soil pipes, &c.

In Section 23 of the Public Health Act 1875, the words "sufficient for effectual drainage" in the absence of regulations embodying the necessary details of effectual drainage, are not sufficiently clear, and the latter part of this section as to what the local authority may require, only applying to materials, size, level, and fall, does not go far enough.

It appears to the author that in place of the vague reference in Section 21 to the regulations of the local authority, local authorities should have ample and clearly defined power to enforce the necessary details of drainage and sanitary arrangements of existing houses, including ventilation, adequate flushing, disconnection of waste-pipes, concreting, plumbers' work, such as alteration of unventilated soil pipes and removal of pan closets, and to require the depositing of plans.

Probably a general Act of Parliament would be more effective than giving local authorities the option of making or not making bye-laws or regulations.

After carrying out a new system of sewerage, to defile it, as is frequently the case, by connecting old and horribly defective house drains, should be strictly prohibitory.

The author has had frequent proofs of the inconvenience of the present roundabout way of obtaining the necessary authority to enter premises and open the ground in order to ascertain whether or not a drain sufficient for effectual drainage existed.

In many cases the difficulty was got over by the system adopted when excavating for the sewers, of noting in a book for the purpose particulars of every house drain met with.

More assistant sanitary inspectors or special drainage inspectors are required, and their services would be amply repaid.

There should be periodical and systematical house to house inspection and testing of drains, and power given to enter at reasonable hours, and open the ground whenever necessary for such purpose.

Notwithstanding the complete new sewerage and house drainage, the average death rate is still about twenty, and in 1884, when there was an epidemic of scarlet fever, it was twenty-two.

This high rate for such a district is accounted for principally by the fact that the drinking water is even now derived from the highly polluted shallow wells previously mentioned.

The author strongly advised the carrying out of the contemplated public water supply at the same time as the sewerage and drainage, and prepared a scheme.

Mr. Everard, of Leicester, has also recently designed very suitable works, which have been approved by the Local Government Board, but the permissive character of Section 51 of the Public Health Act 1875, has up to very recently been taken advantage of. In consequence, however, of the action of the Local Government Board, the Local Board have, since this paper was written, resolved to provide a public supply.

Cost of Works.

	£.	s.	d.
9¼ miles of sewers	9,579	0	0
Surface-water drainage	1,500	0	0
Compensation to landowners and occupiers for laying sewers across fields	500	0	0
Sewage disposal works, including an iron lattice-girder bridge 35 feet span, 12 feet roadway, with abutments which cost 320*l.*, widening and embanking the river 300*l.*, metalling roads 320*l.*, small buildings with screen chamber and penstocks, fencing, concrete walling to effluent and storm overflow outfalls, preparing land, sub-drains, conduit-carriers, and distributing chambers, &c.	2,731	0	0
Land 12½ acres at 150*l.* per acre (measured to centre of river), including conveyancing and land for approach road	2,220	0	0
Engineering expenses	717	8	6
Cash now in hand for cottage on farm, expended for supervision of house drainage, and for connecting a few efficient house drains, &c.	1,752	11	6
Total	£19,000	0	0

Borrowed 19,000*l.* at 3¾ per cent., to be repaid in 30 years.

	£.	s.	d.
Cost per head for new sewerage, including compensation and engineering expenses, about	1	18	5
Ditto, for adapting and supplementing old sewers for surface drainage, including engineering expenses	0	5	9
Ditto, sewage disposal, including all the works, land, and engineering expenses, but not the cottage	0	18	6
Ditto, sewerage, surface drainage, and sewage disposal	3	2	8
Cost per acre for double digging and levelling surface, reckoned on area actually cultivated	40	7	0
Ditto, for double digging only	30	5	0
Ditto, forming ridge and furrow (or 1*d.* per yard run of furrow)	9	4	0
Ditto, stripping and burning turf, contract price Actual cost about 5*l.* an acre	10	0	0
Ditto, for sub-drainage, including inspection chambers, 15-inch tide flap, and 15-inch penstock	42	5	0
Ditto, cement concrete and earthenware pipe carriers, including distributing chambers	37	2	0
Cost, buildings only	125	3	0
Ditto, fencing	90	0	0
Ditto, concrete walls to storm overflow and effluent outfalls	108	15	0

House Drainage.

	£	s.	d.
The amount expended by the Local Board and recovered from the owners was about	8000	0	0
Cost per house, averaging all sizes, for houses actually provided with new drains, about	7	15	0
Ditto, for small cottages actually provided with new drains, average	4	0	0
Note.—Most of the cottages were small, and in many cases there were several to one main drain.			
Cost per house, averaging all but cottages, including stabling, houses with shops, &c., actually provided with new drains	17	0	0
Cost per head of population for houses actually provided with new drains	1	12	10

The house drainage was executed at the rate of 300*l.* to 800*l.* value a month.

Mr. F. D. Clark, C.E., the present surveyor to the Board, designed and carried out that portion of the house drainage which was not done when the author resigned.

Remuneration.

As there exists considerable difference of opinion and doubt as to whether a local authority can legally pay their surveyor for extra duties a commission over and above his salary, it may be interesting and beneficial to many, to know how this question has been dealt with in connection with these works.

The author before preparing these schemes asked the Local Board to settle the extra remuneration.

The clerk wrote to the Local Government Board, asking whether in reference to the employment of the surveyor in preparing and carrying out a scheme of sewerage which does not lie within the ordinary province of his duties, there would be any objection to their paying and to his receiving a sum agreed upon for his services which would render the employment of another engineer unnecessary.

The Local Government Board replied that so far as they are aware of the circumstances of the case, they do not see, if the surveyor is competent to do the work, that there is any objection to the course proposed to be followed by the Local Board.

The author, being appointed engineer, was paid a lump sum for the drawings and specifications, about 1¼ per cent. for the bills of quantities, and an "extra salary" at the rate of 208*l.* a year for superintendence as engineer, and was also paid extra for all other special engineering works designed.

The before-mentioned extra salary was continued for the supervision as engineer of the house drainage; and in addition, for preparing the plans of the house drainage, the undermentioned fees were paid.

		£.	s.	d.
Where the cost of work was under 10*l.*	.. ..	0	7	0
Ditto	10*l.* and under 15*l.*	0	10	0
Ditto	15*l.* ,, 20*l.*	0	14	0
Ditto	20*l.* ,, 25*l.*	0	17	0
Ditto	25*l.* ,, 35*l.*	1	0	0
Ditto	over 35*l.* at the rate of 3*l.* per cent.			

The scale of these plans was 44 feet to an inch; and as houses, streets, &c., in the new survey of the district before mentioned were plotted to that scale, the private drainage plans were tracings from the survey plans.

This scale may seem small, but with the aid of a complete reference, carefully lettered on each plan, no difficulty was experienced.

DISCUSSION.

Mr. E. Buckham, after thanking Mr. Cockrill and Mr. Mawbey for their excellent papers, said: Mr. Cockrill has referred to the automatic flushing. That system of purifying sewers has been adopted within a short period, and I think with considerable advantage; but automatic chambers are not altogether reliable. I have found in some cases, through some cause or other, automatic siphons do not act. There are two or three kinds of patent siphons in the market, but I think they are capable of still further improvement so as to make them thoroughly reliable. Some will work with a large supply of water better than with a small supply; but it is clear that there should be such an adjustment of the siphon that it will work with a large or small supply, otherwise it cannot be said to be reliable. Then with regard to the question of flushing—flushing chambers cannot always be fixed to the sewer, but the manholes can always be made into flushing chambers by an inexpensive arrangement of sluices. I have made this alteration in the sewers of Ipswich, and in the new sewers, the manholes have been constructed on that principle, with very satisfactory results. Mr. Cockrill also refers in his paper to the bad connections between house-drains and the sewers. That is a trouble, I believe, every surveyor and engineer who has charge of drainage work, particularly in old towns like Great Yarmouth, Norwich and Ipswich, has to encounter. Even if you are ever so careful and have ever such a good system of supervision, there is a great deal of difficulty in getting the house-drains properly connected. Mr. Mawbey suggests that the connection of old drains with new sewers should be prohibited. I don't see how that is possible in draining an old town which has an old system of sewerage. In laying the new sewer you must connect the old drains with it, and I see no way out of the difficulty. Of course, in time, when the new sewers are laid, you can get the drains reconstructed; but I don't see how you can prohibit their being connected with the sewer. Then with regard to sewer ventilation. I am not surprised at the objection Mr. Cockrill has referred to, of open ventilators, level with the street surfaces. I am one of those who have always thought that open sewer ventilators level with the street surface are a mistake; the system is certainly a mistake, in my opinion, as carried out at the present time. I would not say that there should be no opening in the street, for I think a small opening might be very desirable, but the idea that a sewer should be ventilated entirely by these gratings is a great mistake, particularly in towns where there are narrow, busy streets, as there are at Ipswich. In my opinion, the ventilation of a system of sewerage should be mainly dependent upon upright shafts in connection with open gratings on the street surface, and I consider that the maximum area of ventilating pipes in a certain street should slightly exceed the maximum area of the opening of the grating level with the street surface. Then you will get, in certain states of the atmosphere, a downward current in the grating, and an upward current in the ventilating shafts. So far as I have been able to study the question up to the present time, I believe that to be the best means of ventilating a system of town sewerage. As to the use of sea water for street watering, I should like to say that, some years ago for the information of my Corporation, I made some extensive enquiries upon the subject. I think I sent to Leicester about the use of Cooper's salts, and I made enquiries at Portsmouth about the use of sea water. Mr. Greatrix was the Surveyor at Portsmouth at that time, and he said they had used sea water and found it very objectionable, and injurious to all kinds of fancy goods, particularly plated goods in jewellers' establishments. I never could see the force of the objection, and I only refer to it now because I see Mr. Cockrill quotes, on the third page of his paper, in support of the plan, the experience of Portsmouth.

Mr. Cockrill: Mr. Boulnois is just laying down a scheme for supplying salt water, very similar to my own.

Mr. Buckham: I noticed this point because of the reply I got from Portsmouth. I should like to say a word about cement paving, and to show you a specimen of what I am laying down in Ipswich. I was very gratified to see the excellent paths Mr. Cockrill has got here. They are the best cement paths made from shingle I ever saw; but there are certain objections to cement paths made from shingle, more particularly in my own town, perhaps, than in Great Yarmouth—they cause a great deal of inconvenience to the public in laying, and in the next place it is very awkward in laying gas and water-pipes to have to cut them up; and then there is the liability of cement to expand or contract. I have made all my cement pavements in blocks, similar to the York stone, and I have prepared them in different ways, varying the proportions of materials used. I have come to the conclusion that to make them of pure fine sharp sand is a great advantage, because when they are made in that way, you can dress them just as you would dress ordinary pieces of stone for masons' work. I was rather inclined to think I had done a good thing when I arrived at this particular way of making blocks with pure sand and cement, but there is a paragraph in Mr. Cockrill's paper which has somewhat damped my courage. I can speak very highly of the durability of all kinds of cement pavement, but I cannot speak of the durability of this. I am, however, prepared to say that it will last as long as, or longer, than the hardest piece of York stone. The composition is two parts sand to one part of Portland cement. I have found the Victoria stone wears, as near as I can judge, 100 per cent. better than the hardest York stone. I am very glad to see that the Corporation of Great Yarmouth have taken up the question of public slaughter-houses, which I believe very materially improves the sanitary conditions of all large towns.

Mr. GOODYEAR: I have been laying down some cement pavement at Colchester, and, by way of experiment, I introduced a piece of York stone in the middle of the footpath. From what I can see at present I really believe the concrete will last the longest. It is made of sharp sand and cement. My Council have given me permission to go on in an extensive way.

The CHAIRMAN: At what cost?

Mr. GOODYEAR: 2*s* 3*d*. per superficial yard.

Mr. MEADE: I think we have had an interesting and instructive meeting, and I have listened with much pleasure to the papers that have been read. I should like to ask why Mr. Cockrill did not carry up the salt water tower, say 10 feet or 15 feet higher, in order that water might be available, from this source, for all parts of the town in case of fire, and for the supply of baths. It seemed to me the tank was rather low, although, of course, Mr. Cockrill is better acquainted with the levels than I am. I was very pleased to hear him say that the Otto gas-engine is doing such good work. I have had two of these engines at work for the past eighteen months, and I can fully bear out what he has said in their favour. With regard to the concrete pavement, I was glad to see the condition of the footpaths here. My Board laid some Victoria stone in 1880, and since that time concrete has been laid as a foundation for asphalte, both compressed and elastic, but I don't think we could, with London traffic, lay concrete pavement under the same advantage you do in Yarmouth, nor have we local material suitable for the purpose. I don't think the concrete kerbs would answer in towns where there is a large traffic, although they seem to answer here very well indeed. Going to Mr. Mawbey's very interesting paper, there is one part which refers to the opinion of the Local Government Board as to what a drain should be for the sufficient drainage of a house. I had some cases of the kind very recently which were decided by arbitration. In one case, a gentleman contended that his drain was sufficient, and submitted that the Board could not legally act under Section 23, and should have worked under Section 24, which would not compel him to pay the cost of making a new connection. However, the arbitrator gave his decision against the gentleman and he had to pay the costs. The question of remuneration for extra work comes rather home to me at the present moment. The auditor is now talking of surcharging my Board in an amount they recently paid me for extra engineering works. It seems rather hard that the local surveyor, if he is competent, should not be paid for doing extra work. When the Public Health Act was passed in 1875, the surveyor's duties were very different to what they are at present. We all know what enormous strides have, in recent years, been made in sanitary engineering. We now have extensive water and sewerage works, where a few years since the requirements of the people were met by shallow wells and cesspools; consequently, engineering works of considerable extent now come under the supervision of the local surveyor. If, in some cases, he does not get the opportunity of carrying out the works in the first instance, he has to keep them in order subsequently, and in some to patch up the blunders of the designer; therefore, I say, a man should be paid according to his work, if competent to undertake it; and I think it would be very hard if the Local Government Board were to surcharge a local board for compensating the officer for extra duties which they cast upon him.

Mr. Bately: I think I understood Mr. Mawbey to say that the death rate at Market Harborough was 20 in the thousand, and that vegetables were grown upon the sewage farm. I should like to know whether he has found out what becomes of these vegetables—whether they are sold to the people in Market Harborough, and whether there is any connection between the consumption of these vegetables and the scarlet fever?

Mr. F. J. C. May: I was very much interested in the subject of footpaths, and I believe that cement pavements of some kind or other will be the pavements of the future. At Maidstone, at the present time, we are spending 5000*l.* or 6000*l.* in laying cement pavement—that known as "Stuart's Patent Granolithic Pavement." It is composed of crushed granite and cement, specially manufactured and prepared by Messrs. Stuart themselves, at their factory on the Medway. It seems to us it will give universal satisfaction. There were some parts of it damaged by frost; the contractors, I think unwisely, having carried on some of the work nearly up to Christmas. They were, however, bound under contract to put right any of the paths which were damaged during the carrying out of the contract. They are now taking up all the damaged portion, and we have been very pleased indeed to see the great efforts they have had to make to break up and cut out these particular slabs. It seems to us to have set very hard indeed, and I think that speaks well for its wearing properties in the future. We, unfortunately, are not in the same position as Mr. Buckham and Mr. Cockrill. We have not on the spot the proper materials for making the concrete, and, therefore, have to go further a-field for them. This pavement is being laid for us at a cost of 4*s.* per yard. We borrowed the money to execute the works, and the Local Government Board sanctioned the loan for twenty years.

The pavements we have seen to-day are very good and cheap. I congratulate Mr. Cockrill on his success, and thank him for his interesting paper.

Mr. Henry Miller, Junr.: I should like to ask Mr. Mawbey to give a little more information upon the self-cleansing properties of the main sewers at Market Harborough, which are of small diameter and have but little fall. There is no surface-water going into them, I understand, so that they would not get choked with road *detritus*, but I think it is rather important to know whether there is any deposit at all, because it seems very unusual that sewers with a very small quantity of sewage passing through them—the population being very small and scattered—and with no flushing, such as storm-water would give, should be kept free from deposit in a district where there is no water supply but from shallow wells. Have they been thoroughly examined? Because three years is a short time in which to prove that they will carry off the sewage. It also struck me that it was rather an unnecessary expense to cover the pipes with concrete. I suppose it was done for the purpose of making the joints water-tight in wet ground, but I think it would have been equally well done in clay puddle, which would have given easier access to the pipes, if an extra junction were required, or a blockage occurred.

The Chairman: I consider both papers of considerable importance, and I should like to have said a great deal upon them, but I must confine my remarks to reasonable limits. I happen to know a good deal about the Market Harborough Sewage Works, having taken the trouble to go over them with Mr. Mawbey. I am deeply interested also in everything we have seen which Mr. Cockrill is doing in Great Yarmouth, and I would only say that I think the authorities of Great Yarmouth are fortunate in having such an active and intelligent surveyor. He is carrying on a most excellent work in a spirit of originality. His work, comprising as it does, the watering of streets and the flushing of the sewers with sea water, has in it elements of originality. It is quite clear he is on the right track, and I hope he will succeed. I am favourably impressed with the idea, and there is no doubt whatever as to the economy of the system. With regard to cement footpaths, there are very few towns in England in which you will find a greater number of such footways than we have seen to-day, and it speaks well for them, that we have seen paths laid fifteen years ago which appear almost as good as new. No doubt you have very excellent material in Yarmouth for making these footpaths, but whilst Mr. Buckham and Mr. Cockrill have had great experience in laying these paths, they will not take it amiss if some of us slightly differ from them as to the way in which they carry out their work. It may be they are right—time will prove—but I don't quite agree with Mr. Cockrill as to the necessity for wood splines. I don't think they contribute to the good appearance of the footways, and I would much rather see a neat joint. Mr. Cockrill seems to think it is absolutely necessary to have these splines as a precaution against the possibility of expansion and contraction of the cement. But first of all, the greatest possible care is requisite with regard to the quality of the cement. If you take this care and don't use the cement hot, nor until you have thoroughly tested it for some time, I think you may dispense with the wood splines, and Mr. Cockrill will pardon me for suggesting that there are towns in the United Kingdom that have already done without them. At the present time Nottingham, which is one of those towns which is generally ahead of us in many respects, so far as the work of the Borough Surveyor is concerned, is carrying out very large works of this kind, and they are certainly not using wood splines. I think it was in 1873 I first saw Italian workmen laying down cement footpaths on the continent, and I have never seen anything in England yet equal to the work they were doing. I believe they were before us in this respect, and they did not use wood splines. Here, footpaths did not crack, but remained perfectly smooth—even smoother than those we have seen to-day. I am laying down in Leicester some considerable quantity of cement work, and I have not used wood splines—I don't see the necessity for them. The footpaths are divided into 6-foot squares, and every intermediate square is left out until the other is set, and by this means I believe we have entirely met the difficulty of expansion and contraction, and that you would by the same system, get better-looking footpaths than we have seen to-day. I must confess, I think your shingle will wear better than our granite, although our Leicester granite is I think harder than the granite we saw to-day. I congratulate Mr. Cockrill on the fortunate position he is in with regard to sewage disposal. That is one of the great difficulties nearly every borough surveyor has to contend with, and I am in one of those difficulties, because we are going to pump our sewage 173 feet, up on to the top of a hill where we have taken 1400 acres of land. Here, Mr. Cockrill has nothing to do but to send it direct into the sea. He has, however, experienced the difficulty all towns have had to meet in the ventilation of sewers. That is a vexed question in which we as an Association are greatly interested and which we certainly have not yet solved. Nor have the chemists assisted us in this direction. I quite agree with Mr. Buckham that the ventilator which is the most perfect and likely to be the most popular, so far as our present knowledge goes, is a combination of surface street ventilators with vertical shafts up the house sides. I would not close the ventilators in the carriageways of the streets except in very narrow streets. I can quite understand that in such narrow places as you have in old towns like Yarmouth, surface ventilators could not be tolerated, but I believe it would be a mistake to close them altogether. If you have a very old sewer to deal with, surface ventilators are likely to become a nuisance; but if you convert them into in-takes, and take the sewer gas up the vertical pipes, you will have accomplished the very best system of sewer ventilation. In Leicester we have fifty high factory chimneys connected with our sewers, and we have adopted the system of vertical shafts carried up the house sides as well. We have fifty of these at work, and we are continuing to put them up, but I am still of opinion that we should not close the surface ventilators. I am satisfied that, however large a number of vertical pipes you may get you will never have enough—you cannot possibly have too many of them. Mr. Mawbey has referred in his paper to Frankfort. I am quite aware it would be contrary to the present English ideas to adopt the system and precautions we took in that town, but I believe we can look upon it as, at any rate, a perfect success. First of all we constructed quite a new system of sewers and house-drains throughout the city. We had *carte blanche* to proceed as we thought best, and we constructed an entirely new system of sewerage for a city of 150,000 inhabitants. We executed the whole of the private drainage on the same principle. We carried the soil-pipes of the houses in varnished cast-iron pipes, with lead joints, right up through the roofs and connected them directly with the sewers. We thus got ventilation through 9000 soil pipes, in addition to the surface ventilators, and if any gentleman goes to Frankfort I should be glad if he would convince himself of the character of the air in those sewers. He can see the sewers flushed and operated upon from chambers and galleries constructed for the purpose, and as easy of access for the public as walking into any gentleman's drawing room, and I think he will become convinced that the ventilation is as perfect as it can be made. I must also say I agree with Mr. Mawbey to this extent, that wherever it is practicable to do otherwise, I should certainly not advise joining old sewers with new ones. Mr. Buckham considers it impracticable, and he will probably be surprised to hear that we accomplished it at Frankfort. We had proper surveys made of the position of the old sewers and drains and knew exactly where they were, and we carried our new sewers alongside of them. We completed our whole system of new sewers and private drainage before we interfered with or touched any of the old sewers and old house drainage, and when we had done that, we set to work to take up the old sewers throughout the whole city, and I very much question whether that has been accomplished to the same extent in any other European city. Time will not permit me to say much that I should liked to have said, but I assure you I have presided over this meeting with a great deal of pleasure.

The CHAIRMAN, in moving a vote of thanks to Mr. Cockrill and Mr. Mawbey, said they were much indebted to gentlemen who gave them papers. He thanked Mr. Cockrill for his paper, and for taking them round the town and showing them the excellent work he was doing. Mr. Mawbey had contributed a most exhaustive and excellent paper, which would have taken a long time to discuss, and he did very much to promote the success of the Association. As long as they had such members, who were so ready to contribute papers on such interesting subjects, they would succeed, not only at their district meetings, but still more so at their annual meetings. He had pleasure in proposing a hearty vote of thanks to Mr. Cockrill and Mr. Mawbey for their papers, and he thought also they should couple the name of the District Secretary for the way in which he had got up the meeting.

Mr. COCKRILL, in replying, said he had been very pleased to do what he had done. He hoped there would have been a larger meeting, but Yarmouth was an out-of-the-way place.

Mr. MAWBEY also expressed his thanks, and both he and Mr. Cockrill said they would reply to the criticisms of their papers in writing.

A vote of thanks to the Mayor for the use of the room brought the proceedings to a close.

The following replies have been received from Messrs. Cockrill and Mawbey:—

Mr. COCKRILL, in answer to Mr. Buckham, said he had found Doulton's annular siphons work perfectly during the time they have been fixed, which is now upwards of two years, but does not recommend them for use where sewage is taken to flush with. All chambers for flushing arrangements by hand prove very costly in the end on account of the men's time required to attend to them. Before submitting his scheme to the Council, he had information from Portsmouth showing that salt water for street-watering there had been a complete success, and the objections made to it were groundless. Although the sample of sand shown by Mr. Buckham is better than anything he had in this neigbourhood, he was confident that paving made with it would not stand traffic as well as that made from shingle, and as a proof of this he took the possibility of its being cut.

In answer to Mr. Meade, he said, the Committee did not consider it necessary to place the tank at a greater height, the pressure now given being not far below that of the water company.

In answer to Mr. Gordon, he said, concrete made with shingle retains the heat more than with any other base, and consequently the expansion is greater. The wood spline counteracts this expansion better than any other joint that he had tried.

Mr. Mawbey, in reply, said he had found it quite practical in old towns to avoid connecting old defective house-drains with new sewers. At Market Harborough, nearly all the old house-drains in the district were condemned, and in no case was a defective drain connected with a newly laid sewer. He was at the present time carrying out some new sewerage in old streets at Lynn, and the same rule was being adhered to. If the house-drains were found efficient, they were at once connected with the new sewer at the public expense. If found defective notice was served on the owner to lay new drainage into the new sewer. The old drains were left connected with the old sewers until the new drains were laid. If, however, the line of the new sewer necessitated the immediate removal of a useless old sewer, as is the case in one instance at Lynn just now, the old defective house-drains are "temporarily" connected, and notices for new drainage are at once served on the owner. As to Mr. de Courcy Meade's remarks on the duties of the borough or local surveyor, local authorities would, he thought, do well in the interest of the ratepayers, to entrust to their surveyor, if he is competent, the designing and carrying out of their engineering works, and to pay him fairly for such extra duties, for it is evident that he should be better acquainted with the peculiarities and necessities of his town or district than anyone else, and in the carrying out of the works there was a very great advantage in the daily personal supervision the local surveyor was able to give. Such an arrangement not only raised the status of the surveyor, but enabled the local authority to secure a better man, and most probably to get their work better done all round. In reply to Dr. Bately, the scarlet fever referred to occurred before any crops were got off the farm. And in reply to Mr. Miller, he said that the sewers had only a few weeks since been examined by himself personally, and were found working satisfactorily. The sewers with flat gradients would be nearly self-cleansing with the increased population they were designed to accommodate, but now they were cleansed by flushing. Better gradients were not available without having a pumping scheme. When concrete was used around the pipe sewers the ground was very unstable (almost a running sand) and contained much water; in such a case he considered concrete absolutely necessary.

During the day the members visited and inspected the cement footpaths and the apparatus for providing a supply of sea-water for flushing the sewers and watering the streets, after which they returned to the Town Hall, where the papers were read and discussed.

ANNUAL MEETING AT HANLEY.

July 8th, 9th, and 10th, 1886.

ADDRESS OF THE PRESIDENT,

J. Lobley, M. Inst. C.E., Hanley.

Gentlemen,—My first duty is to thank the Association for conferring upon me the highest honour in their power, namely, that of electing me as President for the ensuing year. I am deeply sensible of the honour, and it is with many forebodings that I have ventured to accept the position I have been placed in by the votes and acquiescence of the general body of the Members. These forebodings would be greater, were I not fully aware that I shall be assisted by each Member of the Association, and every endeavour made to render my duties easy. In the juvenile years of the Association, which the last twelve years may be said to be, when the first President and founder, Mr. Lewis Angell, was followed by Mr. Lynde, the City Surveyor of Manchester, and then by the engineers of the principal cities and boroughs of the kingdom, namely, Liverpool, Birmingham, Bristol, Leeds, and Newcastle-on-Tyne; and the first University of the world, the interesting and charming city of Oxford; there was a reciprocity in the arrangement by which they successively filled the presidential chair. Members holding such positions owed little to the young Society, and, indeed, conferred honour upon it by presiding at our meetings, and giving us the benefit of large and varied experiences. I cannot but feel that in my case the honour is so much the greater in being asked to follow such predecessors, and that as the Association has now arrived at the age which may be described as its teens, it is now old enough to confer the honour on one who can return little beyond the deep interest he has always taken in its proceedings and success. I may claim to be amongst its founders, and have been fortunate enough to have been able to have taken part in every annual meeting since. This may well be described as good fortune, for I have never required to be absent from any meeting of my own town council or committees in order to do so.

The objects of the Association have so often been ably set forth in the addresses of your former Presidents, and I should only be imperfectly going over the same ground if I attempted to state at length what they are—suffice it to say that our Association consists of between 200 and 300 Members, each representing an urban sanitary authority. We hold meetings in various parts of England; inspect important works, discuss sanitary science in all its branches, and in the words of Rule 2, "Promote and interchange among the Members that species of knowledge and practice which falls within the department of an engineer to a local authority."

During the past year the Council of the Association has instituted a system of voluntary examinations in all branches of knowledge requisite to those desiring to be surveyors to sanitary authorities, and the result of the first examination held gives promise that this has been a wise step, and will lead to great benefit in future to all concerned. Your Council has also given attention and consideration to a proposed change in the Public Health Act, 1875. For several years past a Bill has been brought into the House of Commons to amend section 150. This is one of the most important sections; indeed, I might say, as regards town surveyors, the most important section in the Act. Those who have had much experience of the working of the existing law, including in that expression the corresponding clauses of the Acts of 1848 and 1858, know well how imperfect it is, and how greatly there is need for amendment. Before the formation of our Association, the men who had most experience in the operation of a law had no proper means of bringing their opinions before the Local Government Board or Committee of the House of Commons. I can lay claim to twenty-five years' town work, to many miles of private streets apportionments, first in Liverpool, the largest urban authority in England, and subsequently in this town of Hanley. I trust the day is passing away when the practical knowledge thus gained by many of the Members of this Association should not be available to those seeking from time to time to amend the law. Your Council has succeeded by its Parliamentary Committee, in obtaining important additions to the Bill, and, although it is not entirely such as we might desire, there are so many good points about it that its enactment would on the whole be very advantageous. In approving of this Bill, this Association can claim to be regarding solely the interests of the public, both ratepayers and owners of property, because there is no doubt that it will very greatly increase the work of the borough engineer and Local Board surveyor. It is much to be regretted that, after passing through the House of Commons, it should have been wrecked by a side wind in the House of Lords. Without in any way entering into the arguments of those who, in the supposed interests of the railway and canal companies, proposed to exempt them altogether from contributing to the cost of private streets, I venture to think it will be better to continue under the existing statute than that such a clause should become law without a very full and calm consideration. Such consideration could not possibly be given to a clause tacked on to a Bill in the last days of a Parliament; and, indeed, it is difficult to believe that it would have any chance of passing the House of Commons, except in a special Bill of exemptions. What, however, must at once strike all of us, is that the railway and canal companies have been singularly ill-advised in risking the passing of the Bill as brought into the House of Lords. As the law stands now, the surveyor of the authority must apportion the expenses of a street in proportion to the frontages of the property, and cannot take into his consideration that some of the land may belong to a railway company, who do not make any use whatever of the street. The Bill would have made it possible for the local authority to take such a circumstance into consideration, and would also have enabled the railway companies to appear before a tribunal, and to state their case with some degree of assurance that the arguments brought forward would result in some abatement in their expenses. It is nothing less than astounding that those most likely to benefit by the proposed change in the law should have prevented that change, by insisting on a clause, which, in its present bare form, could not have had a reasonable chance of passing into law.

There are several sections in the Public Health Act, on which it would be beneficial to enlarge, and to suggest improvements; but I must now give a short description of the works you will see, and some remarks on the town to which you have come to hold our annual meeting. I do not propose inflicting a long array of statistics, to prove how much work has been done, since my appointment here, fifteen years ago. Such figures, however important to those locally interested, would appear very small beside those used in describing the works carried out in the large towns where we have held our previous annual meetings, such as Liverpool and Birmingham, as well as those where we have had district meetings, as Nottingham and Bradford.

We have nothing very attractive to show you in Hanley. A great deal of work has been done, but to those not conversant with the town fifteen years ago, this is not so apparent as the fact that there is still very much to do. Then we had not one mile of good sewers, now we have over thirty. Then we had not two miles of carriage highways, having sufficient traffic, to cause the cost of maintenance to exceed 150*l.* per mile as macadamised roads, and not one was paved. Now we have above 12 miles of roads with such traffic, and 1½ miles of paved streets. More than 9 miles of main roads were then in the hands of turnpike trusts; these are all now maintained by the authority. The public highways, repairable by the ratepayers, then measured under 12 miles, now they measure over 29 miles. There were no baths, recreation ground, or sewage works, all which we now possess. There was no collection of house refuse by the local authority, but householders had to get it removed in the best way they could. During this period of time the markets have been enlarged, and still require extension to meet the demand upon them. The cemetery has been extended, and as part of this extension cannot be used as a burial ground, it forms the nearest approach to a park that is possessed at present by the Corporation. Since I read a paper on the Highways and Locomotive Act of 1878, at the meeting at Leeds, Hanley has obtained a separate Court of Quarter Sessions, which renders that Act inoperative here, so far as regards contributions to and from the county rates on account of main roads. Thirty streets have been improved by the purchase of lands under provisional orders, and by agreement. The most important in the centre of the town being the widening of Piccadilly, where the tramway turns into Stafford Street; the widening of Old Hall Street and Stafford Street, and the making of Percy Street through from Crown Bank to Parliament Row. Three new bridges have been made over the canal, and two have been widened. There is one special peculiarity to Hanley—one which prevails more than in most other towns, even more than the rest of the Potteries—and that is the extent to which it is undermined

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by iron and coal workings. Almost the entire town is honeycombed—of course to the great detriment of the buildings and pavements on the surface. Ordnance bench marks are no use at all until checked, and that must be done each time they are used. For instance, streets between Hanley Station and the Town Hall have marks which are from three feet to six feet lower level than when taken by the Ordnance surveyors. This subsidence causes gas, water, and sewer pipes, and branches, to give way, and this in its turn causes the roadway surfaces to be continually broken into for repairs. Such pavements as may be seen in some of our large towns must not, therefore, be looked for here, and even the macadamised roads cannot be expected to be as good as they should be when these excavations are so frequently made.

Hanley is a town of more than 50,000 population, and is regarded by its inhabitants as the metropolis of the Potteries. Stockport, 32 miles distant, is the nearest larger town on the north; Derby, 35 miles to the east; Wolverhampton, 35 miles to the south; Dublin on the west; and Sheffield to the north-east. It is therefore the largest town within a circle exceeding 3000 square miles. It is situated on hills adjoining the valley of the river Trent, and within a few miles of the source of that river. The level of the lowest part of its public highways, situated on the south side of the railway and canal bridges, at the north end of Stoke station, being 365 feet above Ordnance datum, and the highest level being 639 feet, near the top of Market Street. The market-place, 557 feet above Ordnance datum, is believed to be the highest of any corporate town in England. At one spot, near Etruria, which is within the borough, and close to the world-renowned potteries of Messrs. Josiah Wedgwood and Sons, it would be possible to stand and pour water, so that some would go by way of the Trent to the German Ocean, some would go north by way of the canal to the Irish Sea, and some would go south to the Thames or Severn.

Referring now to the works in progress, and which you will have an opportunity of seeing, I will commence with the Town Hall. This building, then known as the Queen's Hotel, was purchased by the Corporation in 1884, and adapted to its present purpose, the old Town Hall having become much too small for the amount of business requiring to be transacted there. Offices for the various departments are now provided in one building instead of in different parts of the town. Accommodation is provided for the town council and its committees, also the magistrates and police. Borough justices' courts are held daily, and the county justices hold a court here once a week. The county court has several sittings in the month, held by the judge, registrar, and official receiver. A copyhold court is held monthly, most of the land in the township of Shelton, within the borough, being copyhold under the Duchy of Lancaster. New police cells have been erected, also safe and muniment rooms for the town clerk and borough accountant. In designing the alterations it has been the aim to obtain the greatest result at the least expenditure, rather than to alter existing features for the sake of producing different architectural effects: We are now engaged in erecting a new Quarter Sessions court, Many of the features in connection with this court and approaches are caused by the necessity to adapt it at points all around it with the existing buildings on three sides, and the proposed public assembly hall on the fourth side. The cost of the Town Hall, inclusive of the work in hand, will amount to 15,000*l*., and the public hall, for which 8000*l*. has been borrowed, will bring the total cost to 23,000*l*. The building will cover nearly an acre of ground, having a length of frontage of 152 feet and a depth of 262 feet. The public hall, for which the plans are being made, is expected to accommodate 3000 persons, and when occasion requires it, by removing the seats on the ground floor, as is frequently done in the Birmingham Town Hall, more than 5000 persons can be admitted. The free library is being constructed out of the old Corporation offices, together with the reading room of the Mechanics' Institution, with a total frontage of 136 feet. The slaughter houses are being built adjoining the cattle market and town yard, and consist of six abattoirs, with lairs attached. No doubt, if found successful these will be but the small beginning of a much larger scheme. The public baths were erected in 1872–4, and have been greatly appreciated, last Saturday no fewer than 1200 being admitted to the two swimming-baths. The rest of the establishment consists of private and vapour baths, and a suite of Turkish bathrooms; with manager's residence and laundry.

The markets are a great feature in Hanley, and consist of vegetable market, 180 feet by 93 feet; the fish market, 85 feet by 82 feet; and the butchers' market, 132 feet by 93 feet. A wholesale market is held in the square on Saturday mornings, and a cattle market is provided for weekly sales. At the present time we are engaged in repaving the Market-square. This is done with sets from the Endon quarries, Kerridge, near Macclesfield, on a concrete foundation. These sets afford a firm, non-slippery foothold for horses, and although less durable than granite, are believed to be better for this purpose, owing to the gradient of the Market-square. On streets with less severe gradients, granite and basalt sets are used from Dalbeatie, Clee Hill, and Welsh quarries.

The Bucknall Road canal bridge is a comparatively small work, but is illustrative of the difficulties we have to contend with in this district. This canal, which feeds the Trent and Mersey Navigation at its summit level, is a contour line round the south-eastern slope of the hill; the gradients of the roads leading up to and over this canal are very heavy, ranging from 1 in 14½, which the tram engines have to overcome between Stoke and Hanley, to 1 in 12 on the Newcastle Road, and 1 in 13 on the Fenton Road, and 1 in 11 on the Bucknall Road. The soffit of the bridges must be high enough above the water to give facilities for the boat traffic, and in order not to increase the gradients the road surface must be kept down to the lowest possible point. The depth, therefore, between the soffit of the bridges and the road surface on the top does not exceed sixteen to eighteen inches. This bridge, being on the way to the Sanitary Hospital, may be inspected as an example of all the rest, which we shall probably not have time to see. It is, however, much the smallest, the span being less, as well as the width of the road. The special feature about it is that you will be able to see the points from which it has been twice raised in consequence of subsidence through coal workings. The water-level remains unaltered, but as the banks and bridges subside, so must they be lifted. The first raising took place in 1883, and the second in 1885, and it is expected to require raising again next year. The bridge itself is constructed so that it can be divided in two in the middle, and one half raised with pavements complete, while the traffic is using the other half, afterwards completing the remainder. There is no other road into which the traffic could be turned except by a very great detour. The most costly part of the operation is, however, not raising the bridge, but adjusting the road levels on each side of it, and each raising makes the gradient worse. The retaining walls on each side of the road are also built thick enough to allow for several subsidences and extensions upwards.

The Hanley sewage works formed the subject of a paper read by me at the District Meeting of the Association, held here in May 1881, and therefore need not be again described.

PAPER ON RECENT SEWAGE OPERATIONS IN NOTTINGHAM AND ITS NEIGHBOURHOOD.

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Having been requested by the Council of this Association to give a few notes on the extensive sewage works which have, for some time past, been in course of execution at Nottingham, at the present Annual Conference in the town of Hanley, the author gladly complies with their request, but fears that what he has to say will not present that compactitude and order which such a subject demands, and which is and ought to be expected by such an important association as the one he has the honour now to address. The comparatively few hours he has had at his disposal, in the midst of a busy time of the year, must be his excuse for omissions, imperfections and other defects.

Nottingham is one of the large towns of England, ranking the sixth in size and population, after the Metropolis, and is also one of the oldest boroughs.

Its Charter is prescriptive; that is, the precise dates of the ancient rights and privileges of the burgesses are not known, but one of the earliest charters on record is that granted by Henry II. It possesses others also by King John and subsequent sovereigns. It thus has a prerogative, second only to that of the City of London. Whatever the value of this may be, modern legislation, as applied to all large English cities and towns, has conferred great powers, large duties, and corresponding responsibilities on the Municipal executive.

Nottingham occupies a very central position in the Midland Counties, near the southern point of Nottinghamshire; is about 120 miles from London and 100 from Leeds. The distance to the sea on the East Coast is about 52 miles, and on the West Coast about 85 miles. It therefore may be called a distinctly inland town.

The borough is a county of itself, and the centre thereof lies in latitude 52° 57′ north, and in longitude 1° 9′ west.

The area of the borough is 9,960 acres, and the present population is 232,000, but nearly 240,000 people contribute to the sewage volume.

The present rateable value of property in the borough is 910,000*l.*

Both the Gas Works and the Water Works are the property of the Corporation; the former supply gas to the borough and to thirty-three outside parishes, which in the whole cover an area of 133⅓ square miles and a population of about 270,000; and the latter supply water to the borough and to twelve surrounding parishes, which altogether cover an area of 64⅕ square miles, and a population of 257,000. Incidentally it may be mentioned, that the quantity of gas supplied during last year was about 1,200,000,000 cubic feet, and the quantity of water raised for distribution was about 2,000,000,000 gallons.

The annual mean temperature in Nottingham is 47° 5′, and the average annual rainfall about 27½ inches. The actual rainfall last year was 26·662 inches. During nineteen years continuous observations the lowest annual rainfall the author registered was 17·934 inches, and the highest 35·903 inches, the highest being exactly double that of the lowest. If the average annual rainfall of the last half century be taken the amount would be found to be less than that above quoted by more than an inch.

Topographically, the greater part of the borough of Nottingham lies upon undulating ground, and at the base of a series of hills which extend from Sherwood Forest to the Valley of the Trent, and which have their termination in bold escarpments or gentle slopes on the north side or left bank of that river. The extreme southern portion of the borough, which is populated principally by the artizan classes, but which also contains numerous factories and industrial establishments, lies upon the large alluvial area extending from the aforesaid escarpments to the river Trent. This portion is extremely low and flat, and requires to be raised considerably before building operations can be carried on.

It is made imperative under the special provisions of a local Act of Parliament that all buildings shall be erected above the highest flood-level, and that level was officially determined by the author some years ago. It would be very fortunate if the same powers in respect of this matter, obtained by the Nottingham Corporation, could be extended to the local authorities of many other towns in this kingdom. Of course the physical nature of the district just referred to, created many difficulties in public sewerage and private drainage, but these have had to be overcome by special devices and somewhat costly works. The very steep gradients in other parts of the borough have frequently been productive of much inconvenience, particularly during storms and heavy rain, when the lower parts of the district are liable to be suddenly deluged.

Geologically, the largest portion of the borough is upon the Triassic series, which predominate on the southern, eastern, and northern parts of Nottinghamshire. The southern part consists mainly of the Keuper beds of the new red sandstone, and the eastern and northern of the Bunter or conglomerate rocks. In all these strata very little water is met with at the depths usually required for sewerage purposes, except that occasionally a spring is tapped, fed from some distant hill. In the town, however, the rocks have been so extensively pierced for local supplies of water, that the general water-level is reduced to a very low point. On the western side of the district the Permian system prevails, overlying the coal-beds which extend into Derbyshire. Here, after passing through the rich ferruginous clay, the magnesian limestone rocks are reached. These are exceedingly hard and semi-crystalline, and break up into amorphous blocks, which are used for building stone, or calcined in small kilns to produce a building lime. The beds generally are full of water, and cause considerable trouble and expense in the construction of sewers, and in mining operations and other underground works.

The river Trent is identified with Nottingham, and flows through a portion of the borough on the south side. If it were not for the enormous volume of water which is everlastingly scouring its bed and carrying away to the sea the daily refuse, manufacturing and domestic, of upwards of two millions of people, between Cheshire and the Humber, including the more or less purified sewage of Birmingham, Leicester, Derby, and the Potteries, including Hanley, it might be fairly termed a mighty sewer.

Next to the river Thames and the river Severn, the respective watersheds of which are about 5356 and 4360 square miles, the river Trent is the longest and the largest river in this country. It possesses a drainage area of upwards of 4050 square miles, nearly 2900 of which are above the town of Nottingham. Its total length is about 150 miles. The river rises on the hilly borders of the counties of Staffordshire and Cheshire, near a place called "Mow Cop." It flows thence in a southerly and south-easterly direction, until it gains the heart of the Midland Counties at its most southerly point, which is about half-a-dozen miles to the north-east of Lichfield. Here it is joined by the river Tame and it then takes an easterly and north-easterly course for many miles until it arrives at Nottingham. From the latter place it travels to Newark, and then follows a direction almost uniformly northerly, until it joins the estuary of the river Humber, at Trent Falls, a little to the east of the point where the Yorkshire Ouse, which has an extensive and complicated watershed, has its debouchure in the aforesaid estuary.

Another river, of small dimensions, and to which much reference will have to be made, flows completely through the borough along its major axis. This little river, immortalised of Byron, is called the Leen, and is about 14½ miles in length. It rises in the Forest of Sherwood, among the Robin Hood and the adjacent hills, and unitedly with several tiny streamlets flows on to the Abbey of Newstead, where, being arrested by an embankment opposite the abbey, it becomes a large and beautiful lake. Wending its way therefrom, through the grounds of Newstead, it is again impounded, and forms the large lower lake, from which, after receiving several accessories of strength and beauty, it directs its course towards Papplewick. Leaving this place, it descends southwardly to Bulwell, in the Borough of Nottingham. From thence it passes, as before stated, through the borough viâ Basford, Radford, and Lenton to the foot of the Castle Rock in Nottingham. From the latter point to its junction with the Trent below the Trent Bridge, it is culverted and forms a large sewer 9 feet by 7 feet 6 inches, with a discharging capacity of about 15,000 cubic feet per minute, or 138 million gallons per day.

During the last year or two, however, this river Leen has been diverted from its old course at Lenton and turned into the adjoining canal, therefore its bed between the point of diversion and the Castle Rock has been filled up. The large culvert or sewer through the town to the Trent above mentioned, nevertheless remains and serves the purpose of an outfall sewer and forms part of the sewerage system on the south and west sides of the borough.

Another small river exists on the eastern side of the town, which has caused more anxiety and money outlay than any other. This may veritably be termed a sewer river, inasmuch as it carries away along with its own pure spring waters, the foulest and most concentrated sewage of the borough. It is called the river Beck, and rises on the Mapperley Hills, within the borough, to the north-east. It is fed by springs and traverses the very heart of the borough and joins the Trent about a mile below the bridge.

It has been gradually covered over during the last forty to fifty years, and is now culverted from end to end, forming a combined river and sewer. It can be quite understood how the difficulties of treating sewage are enhanced by such complex conditions as are attached to an outfall of this description.

Operations have been in progress for some time past for dividing the sewage from the natural waters of the Beck, and these have involved, *inter alia*, the construction of an enormous and independent storm-water culvert, commencing at the river Trent, and extending to a point in the centre of the Beck valley. The size of this relief culvert is 10 feet circular at the outlet, which size is maintained for a considerable distance; it is then gradually reduced in size to five feet circular at the upper end. It is, of course, capable of being continued higher up the valley when required. The great size of the culvert was not due altogether to the work of division, but to provide for the rapid removal of excessive rainfall in the valley. Of late years the valley has been almost completely built over, and the sides being steep, and the many miles of streets being paved, the rain, in a heavy storm, accumulated so quickly in the low levels as to cause not only great damage, but occasionally absolute destruction of property.

Having described the general features of the district, the modern operations of sewerage and sewage disposal will be referred to.

Prior to 1859, when the author was appointed Engineer to the Corporation (the first engineering appointment of a consolidated nature), the town was governed by several authorities, and of course was misgoverned. There existed the Corporation, the Inclosure Commissioners, the Lighting Commissioners, numerous Highway Boards, and other bodies. With the exception of the Inclosure Commissioners, whose powers ceased and trust terminated under a special Act of Parliament in 1867, and whose duties and responsibilities were then vested in the Corporation, all the old governing bodies in 1859 died, and all their powers were transferred to the Corporation. The town then became entirely under the direct control of the Corporation under the Municipal Corporations Act, the Public Health Act, and other incorporated Acts, and by special local Acts of Parliament.

At this period, as in the case of most large towns of that date, the condition of the sewerage was bad in the extreme. The majority of the many miles of streets certainly had sewers, *sui generis*, and the public claimed therefrom immunity from every zymotic evil; but it was soon shown to an intelligent community that a radical alteration was imperatively needed. Operations of sewerage were at once commenced on the most modern and thoughtful lines and the principles then established have been continued up to the present time.

In Nottingham, bricks are especially good; made either from the Keuper shales or the Permian clays (a specimen of those made from the Keuper beds may be seen at St. Pancras Station and hotel, all the bricks in these buildings having been made at Nottingham from local clay); hydraulic lime, from the Lias beds in Leicestershire, is close at hand; sand from the silicious beds of the Trent, of a singularly clean and angular nature, is abundant; stone from Derbyshire, of various qualities, is prolific and cheap, and thus all the elements for good and substantial work present themselves in the immediate neighbourhood. The sewers, therefore, have been made mainly of brickwork, and the ordinary sizes of the secondary and inferior sewers range from 4 ft. 6 in. by 3 ft. to 2 ft. by 1 ft. 4 in., egg-shape. Smaller sized sewers are made of glazed earthenware pipes, down to 9 in. in diameter, in short and small streets, and in courts and alleys. It may be at once, and very shortly said, that side entrances are provided at all important junctions; manholes, combined with ventilators, are built at regular intervals; flushing gates are fixed at selected points on the main trunk lines, and special ventilation, at summits, is attained by carrying up iron shafts attached to the nearest and most convenient building.

For many years after 1859, all the sewage of Nottingham and the surrounding districts, was delivered into the rivers Trent or Leen, with the utmost tranquillity, but the *Nemesis* at last appeared. The river Leen, once upon a time the source of water supply to the town, became black and blue and stinking; the Trent, then affording a portion of the water supply (certainly above the point of sewage outfall), lost its silvery character; the riparian owners commenced a tirade against the Corporation, hoisting the flag of Chancery, and at last it became compulsory to devise some method of treating the sewage, and if possible some mode of extracting pecuniary compensation from a pre-acknowledged nuisance.

The outside districts, Sneinton, Lenton, Radford, Basford, and Bulwell, outside only in name, for they are and were intrinsically as much part of the urban area of Nottingham as Salford is of Manchester, and Southwark is of London, were approached on the general question. Numerous consultations and negotiations took place between the authorities of Nottingham and the aforesaid districts, and the result was a Bill conjointly promoted, and an Act subsequently obtained for the constitution of a Sewage Board, consisting of the *quasi* united districts, and forming a temporary heptarchial parliament, for the purposes of outfall sewage and sewage utilisation.

It was understood that the confederation described should in nowise interfere with or disturb the internal or local sanitary management of each town, but that the permissive principle indicated by the Sewage Utilisation Acts 1865 and 1867, whereby sewer authorities may combine together for the purposes of constructing and maintaining any works that may be for the benefit of the respective districts, and of forming a united district for sewage utilisation, should be made compulsory and absolute, and that the requisite executive machinery should be established.

The Act was passed in 1872, and in its passage through the House received the hearty commendations of the Government; its title was the 'Nottingham and Leen District Sewerage Act.' This measure, the details of which were comprehensive and effective, provided for the following matters, viz.:—

a. The definition of a district or watershed area within and over which the powers of the Act are applicable.

b. The constitution of a Board or body Corporate, having perpetual succession and a common seal.

c. The construction and maintenance of intercepting sewerage works in the Leen Valley.

d. The construction and maintenance of outfall sewerage works, and the purification or utilisation of the sewage.

e. The conservancy of the river Trent and the river Leen, and their several tributaries.

f. The extension of the powers of the Act, under certain conditions, to places outside the prescribed district.

g. The raising of money for the objects of the Act.

Similar Parliamentary powers were afterwards obtained by the Borough of Birmingham and its immediate suburbs, and the extensive sewerage works in the Valley of the Tame are now being executed under an Act, uniform almost to the one now being described, and are calculated to afford great advantages to the large and increasing population in that part of the Midland Counties.

The first operation of the Joint Sewerage Board was the providing a general Intercepting Sewer in the Valley of the Leen, and the connection of the same with the large Leen sewer or culvert near the Castle Rock, in the Borough of Nottingham, previously described. This, of course, brought all the valley sewage, in a concentrated form, into the river Trent below the Trent Bridge, and was intended to eliminate all sewage from the river Leen. The sewer, as executed, is 30,837 feet in length, or nearly six miles. After its junction with the culvert in the town, it passes through the Park and along the valley through Lenton, Radford, Basford, and Bulwell, and terminates at the north end of Bulwell, near the Forest. It crosses under the river Leen seven times, and the railways four times. The section is circular, 5 feet in diameter at the commencement, and circular, 18 inches in diameter at the upper end; the intermediate parts are egg-shaped or circular, according to circumstances. The gradients vary from 1 in 1760, or 3 feet per mile, to 1 in 264, or 20 feet per mile. The total fall from the upper to the lower end of the sewer is 70 feet 6 inches, or an average of 12 feet to the mile. The discharging power of the sewer, at its lowest part and flattest gradient, is equal to 3097 cubic feet per minute, or 27¾ million gallons per day uniformly delivered; at another important point in its course, that is, about halfway between the two ends, its discharging power is equal to 1800 cubic feet per minute, or 16 million gallons per day. In giving the discharging capabilities of the intercepting sewer and of the outfall, or any other sewers herein referred to, they are calculated to be running at their maximum, that is, when not quite full.

The highest discharging power of a circular culvert is attained when the same is filled and running within a segment or arc of about 308 deg. 12 min.; a sewer 5 feet diameter would, therefore, be short of full by a depth of about 4 inches at the crown.

Provision is made at several points in the course of the sewer for the overflow into the Leen of storm-water. It would be impossible for any ordinary sewerage works constructed in a reasonable manner to deal with storm-water, over such a large area, when from a quarter of an inch to nearly two inches in depth fall in the space of an hour, particularly when the district contains so many steep surfaces, built over or paved with hard and unabsorbent materials. All such rainfall is therefore liberated as quickly as possible into the nearest streams, river, or canal.

The egg-shaped portions of the sewer are 4 feet 6 inches by 3 feet, 3 feet 9 inches by 2 feet 6 inches, and 3 feet 6 inches by 2 feet 4 inches. From Basford to the upper end of the sewer, a length of about 2½ miles, the sewer is constructed of cast-iron pipes, the greater part being 2 feet in diameter, and the residue, towards the summit, 18 inches in diameter. This was necessitated by the wet and boggy nature of the ground. The joints were turned and bored, having also a socket beyond the faced surfaces of the ordinary kind, which was filled and set up with tarred gasket, so that not only the body of the tube, but also the joints, were rendered sound and water-tight. Earthenware pipes were at first attempted to be used, but it was found impossible to make or keep them tight, and in consequence iron was resorted to.

One word may be said, *en passant*, on the subject of water-tight joints. If sewage is intended to be conserved for the purposes of irrigation, or even for any chemical treatment, it must be preserved free from extraneous fluids. It is very easy to double or quadruple the sewage volume of a district by absence of thought and care in the fixing and jointing of earthenware pipes, which form in numberless cases the staple material for town drainage. In soft and spongy ground clay joints are the best, if they can be made initially sound and be sustained and surrounded by puddled clay. Cement joints are good on hard ground, but in wet and changeable strata it is difficult to secure a joint which will hold when the cement is set and the line of pipes inevitably, though but slightly, disturbed by the filling up of the trenches. The author has constructed water-tight sewers several feet deep (10 feet to 15 feet) in the wettest ground, by the use of long socket-joints made with bitumen and cement, and surrounded bodily with puddle, but the expense is great, and the difficulty of making after-connections becomes so troublesome that it is cheaper to resort in the first instance to a more adaptable material. He now invariably uses iron pipes for sewerage purposes in land where springs abound, and bring up iron junction-pipes for each house or for each block of houses, more usually the latter, to a point above the natural water-level.

The residue of the attachments can of course be made by the ordinary glazed terra-cotta, commonly termed earthenware or stoneware pipes.

The portions of the sewer not of iron were constructed of brickwork laid in ground lias lime and washed Trent sand, in the proportions of one of the former to two of the latter. The usual means of access, flushing, cleansing, and ventilation were of course provided.

The cost of the intercepting sewer last described, was a little over 50,000*l.*; this included owners' claims for easements and tenants' compensation for injury to crops and property.

On this subject the author wishes to remark that the most bitter feature connected with work of this nature is the sinful enormity of the claims made by landowners and others for so-called "damages." In most cases their estates are substantially improved, and not infrequently, after the settlement of their claims (sometimes following an expensive arbitration) their land is brought into the market for building purposes with high-sounding sanitary qualifications.

During the past few years great pains have been taken, and a large outlay of money has been incurred in connecting all branch sewers with the intercepting sewer, and in attaching the drainage of house and other property. Manufacturing refuse has not been turned yet, as a matter of principle, into the sewer, although a large quantity finds its way thereto by means of the internal system of sewers. This (the removal of manufacturing refuse) is an important question, which will shortly be referred to, for it affects not only the magnitude of every sewerage undertaking, but the cost and ultimate loss, which is always identified with the disposition of fluid excretions.

On the completion of the intercepting sewer, the next consideration for the Sewerage Board, was not the cheapest, but the safest and most appropriate means of disposing of the aggregated refuse.

With volumes of blue-books, with unlimited evidences, with the experiences of amateurs, scientists, doctors, chemists, agriculturists, engineers, *et sic de similibus*, the Board were not content, but chose to act upon the grounds which, considering the neighbourhood, and the nature of the substance they had to deal with, appeared to be the most rational and permanent.

The author was instructed to advise the Board, and did so, in a report which was published in the summer of 1875, and which has since been acted upon. The local details which led to the conclusions arrived at need not be elaborated, but it may be stated that his recommendations were to establish a sewage farm for the purification of the sewage, laid out in such a manner as to recoup, as far as possible, the inevitable annual cost which would be entailed.

There was no land in the immediate vicinity of the Nottingham outfalls capable of being appropriated to a mechanical treatment of the sewage. Residences, private grounds and building land occupied all space, and to deal with the sewage by precipitation or chemical processes, it would have been necessary to carry the same at least as far as it is now carried for irrigation purposes. The views the author expressed at the time were somewhat as follow: "I believe that in the case of a hypothetical town or district where the sewage is weak or highly diluted, or where there is a rigid separation of excrementitious matters, also where the outfall is into the sea (free from a bathing shore) or into a river or stream immediately connected with the sea, and with a sparsely populated intervening country; also, where the country in the neighbourhood of the outfall is exclusively agricultural, that almost any of the well-known precipitation systems—in some instances simple subsidence—will be sufficient to render the sewage reasonably free from danger or nuisance, and that irrigation may be made a mere matter of convenience; but I am not aware of any system of chemical treatment that is capable of effectually purifying the sewage of this district as now discharged into the Trent, and of dealing with its soluble organic elements, in such measure as to prevent their becoming an ultimate nuisance.

"I also believe that any deposit that may be induced by chemical action, will have a very small agricultural value, unless fortified by manurial agents. The sludge of precipitation works is practically worthless, the disposal of it is troublesome and oftentimes expensive, and the effluent water is dependent, almost invariably, upon the oxidising influences of the river or stream into which it is discharged, for the conversion of its organic and polluting substances into inorganic compounds.

"The tank, or chemical system, wastes the sewage, effects only clarification and fractional purification, and leaves the liberated liquids to the subtle powers of air and water for their final restoration. This, in some localities, it may with impunity be allowed to do, but I cannot recommend, alone, such a method of sewage disposal to the authorities of the Nottingham district.

"The only alternative is the land or agricultural system: the irrigation of land and consequent utilisation of the sewage, or that associated with natural filtration. It has been abundantly shown that this will, under proper management, cleanse the sewage, fertilise the ground, and produce healthy results; but I do not think the latter must be estimated entirely from a money point of view. The primary obligation of a local authority being the maintenance of a high sanitary standard, all animal and other communital refuse must be continuously removed and disposed of without defiling the water supplies of the country or trespassing upon riparian rights; and although cost is a legitimate consideration, it is of secondary moment.

"When the sewage of a town or district can be preserved moderately free from spring and extraneous waters—where the physical configuration of the surrounding country is favourable—where the sewage can, by gravitation, command a sufficient area of land—where the latter is light, porous, and well drained—where the population is extensive, and the markets near, for the consumption and sale of vegetable produce—and when there is competent direction—I have no doubt that a sewage farm may not only recoup all yearly expenditure, but realise a substantial profit.

"A profit will always be subject, firstly, to the ordinary incidents of farming and the weather; and, secondly, to the conditions which attach to the undertaking.

"When the farm is distant the cost of conveying its products is increased; when the sewage requires lifting by steam-power to a considerable elevation, an annual cost is incurred which militates against profit (if indeed it is fair to couple the cost of pumping with that of farming); when land is dear to purchase, and expensive to lay out, and the markets are limited or inaccessible, all these will reduce the chance of profit, and have in many farms caused an inevitable annual loss." The author therefore recommended the carrying out of a scheme of sewage utilisation, combined with land filtration, as a safety-valve; he held out no brilliant hopes of profit, nor suggested a fear that monetary loss would be inadequately counterbalanced by sanitary gain. "*Nunquam aliud natura, aliud sapientia dicit*," and he had the strongest foundations in this case for the judgment he was called upon to give; at the same time he did not forget the aphorism, "*Felix qui potuit rerum cognoscere causas.*"

To give effect to the scheme unanimously acceded to on the part of the Sewerage Board, a tract of land was selected and ultimately secured, on a lease of sixty years, in the valley of the Trent, and between four and five miles to the south-east of the Borough of Nottingham. The land is the property of the Right Hon. the Earl of Carnarvon, the Right Hon. the Earl Manvers, the Rev. Canon Lord Forester, and William Burnside, Esq. The total area is about 640 acres. The shape is somewhat irregular, as will be seen from the plan now exhibited, but the soil and subsoil are exceptionally qualified for the reception and purification of the sewage. The land is a broad sheet of alluvial drift, overlying the Keuper beds of the new red sandstone.

The Nottingham and Lincoln branch of the Midland Railway is the practical boundary on the north, and the river Trent sweeps the south and eastern sides. The whole plain may be described in general terms as a bed of porous gravel with a thin crust of vegetable soil.

Samples of the strata may be seen in the glass cylinders now produced; these are laid to scale, and were taken *in situ.* The lowest layers in all the specimens are the Trent gravel and sand, over these are more or less conformable coverings of fine sand and gravel, fine argillaceous gravel, fine argillaceous yellow sand, and lastly, arenaceous soil. There are occasional thin beds of clay and seams of silt.

The most unfortunate feature in the undertaking is the heavy rent which has to be paid under the several leases. The land, worth certainly not more than 40*s.* an acre for ordinary farming, was leased for the term referred to, at 5*l.* per acre, and when the cost of preparation is added, combined with the cost of the various buildings and other works, it can hardly be expected that an annual profit would be realised. Nevertheless the yearly loss has not been alarming, but at the same time it should be remarked that only a portion of the sewage has yet been delivered to the farm. That which can be sent by gravitation has been under constant application since June 17, 1880, and since August 6, 1885, a portion of the low level sewage has been sent down by means of a temporary pumping machinery plant.

After the land was secured, the next operation was the construction of the outfall sewer.

About this time an extension of the borough took place, and the districts before-named outside the old borough, were, by common consent, made part of a new and expanded borough. These, as previously observed, were always strictly urban, although, by reason of local political, rather than physical circumstances, they were not under one administration.

In facing and discussing the large contemplated expenditure on the sewage scheme, and the extortionate rent agreed by the expired Sewerage Board to be paid for the land, some public agitation arose and an endeavour was made to modify the plans or resort to a cheaper mode of sewage disposition. Considerable differences of opinion arose, and ultimately, at the author's suggestion, other engineering and agricultural wisdoms were engrafted and digested. The whole proposition was thoroughly investigated by Sir Robert Rawlinson, C.B., Mr. John Chalmers Morton (both of the Rivers Pollution Commission), and Mr. Bailey Denton, and their individual reports so completely endorsed the policy of the scheme and the soundness of its principles, that the works were at once commenced. They have been in progress for some years, and are now approaching completion.*

The outfall sewer will be shortly described. This work commences at Colwick, on the east side of the borough, and extends a distance of about 4½ miles, in a nearly direct line, to the point of delivery at the north-west corner of the farm. It is a gravitation sewer throughout, and is of mixed construction. It passes through woods and meadows and under hills and over lands of various kinds.

The first portion consists of a nearly circular culvert 5 feet 4 inches by 5 feet, and is of brickwork, laid in the best hydraulic lime and clean, sharp, washed Trent sand. Part is in open cutting and about two miles is in tunnel under the Colwick hills, some lengths being as much as 150 feet in depth. At the summit or commencement of the outfall a gauge chamber is built, and here the two lines of outfall from the town and district conjoin ; one being the gravitation section and the other the pumping section. The form of sewer above mentioned continued until some very low land intervened, when the shape was altered to that of a large semicircle with a flat roof or covering, the latter being formed of York landings supported by tee iron girders some three or four feet apart, the whole being covered with soil and afterwards turfed. The sustaining embankment was formed of lias lime concrete, and the size of the sewer was changed to one of 7 feet wide by 3 feet 10½ inches high. Lower down, across some garden and building land, near Carlton Station, on the Midland Railway, two parallel cast-iron siphons, each 3 feet 6 inches in diameter and about 1000 feet in length, were employed. Between Carlton Station and the farm, a distance of about 1½ mile, the sewer is almost wholly on a concrete embankment of a similar section and construction to the upper and last-named embankment sewer, viz. 7 feet by 3 feet 10½ inches, but the earth covering is super-finished by a thick coat of asphalte made of tar, pitch, and clean gravel.

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* That the most anxious consideration of the original Sewerage Board and of the subsequent Committee of the Corporation was given to the subject, in general, I need not call attention to; but there are always diversities of opinion, and perhaps should be, in large works involving public welfare and public expenditure.

Two or three short iron siphons, in double lines, crossing streams and roads, were necessarily involved, and finally the sewer was connected with the large concrete carriers which convey the sewage to all parts of the farm. The length of the intercepting and outfall sewers combined, that is, the distance from the summit of the intercepting sewer to the delivery point on the land, is almost exactly 11 miles. The ruling gradient of the outfall culvert is 2 feet per mile; the total fall in the whole reach of 11 miles is between 70 and 80 feet, and the discharging capacity of the gravitation outfall is equal to 26½ million gallons per day, if the flow were uniform, and the full internal sectional value exercised.

From the town and district the sewage is delivered into the head of the outfall gravitation sewer at Colwick Wood in the following manner:—

It was clearly desirable to carry away as much of the sewage as possible by gravitation, and two points were selected, at coincident levels, in two centres of the town, but about a mile and a half apart, from whence the sewage could be intercepted, diverted and transported, by pure gravitation, but by the agency of (commonly so-called) siphon arrangements to the general outfall.

These siphons, or rather broken lined sewers, were each composed of cast-iron pipes 2 feet 2 inches in diameter, and laid through two of the most important lines of public thoroughfare in the town, but apart from each other, to a convenient point of junction in Sneinton. Here they were united, and the two streams of high-level sewage were conducted in solemn harmony, by means of a cast-iron pipe, 3 feet in diameter, to the gauge chamber at the head of the outfall. The extreme dip of the bended lines was about 16 feet, and the actual hydraulic fall about 7 feet, one bended arm being about a mile and a half in length, and the other about a mile. The pipes were ¾ inches thick, and the joints were turned and bored. These siphons have acted satisfactorily for the last six years, and have required very little attention; of course there are means of flushing out the pipes at the lowest level, and means of access are at intervals provided.

It is very necessary in lines of pipes of this kind to provide for the displacement of air at summits and bends, and as this may be so easily accomplished by means of modern valves and apparatus, there should be no disturbance created to effect the calculated rate of discharge.

The sewage not intercepted, and carried away by gravitation as aforesaid, is required to be pumped. The larger proportion of the sewage, i. e. the sewage from the lengthy valley of the Leen, and the outside places, has to be raised from its lowest level, near the Trent, into the before-described gravitation outfall at Colwick. The lift is not great, statically, only about 12 feet, but friction, bends, and other obstructions, make the dynamic effort equivalent to about 21 feet.

The length of the pumping main is a little upwards of a mile, and the pipe already laid and in partial use (by means of the temporary engine before mentioned) is 2 feet 6 inches in diameter, and circular in section. The thickness of the metal is 1 inch, and all the joints are spigot and socket, made with lead.

The pumping station is now in course of construction, and nearly finished. It is situated near the Trent, on the lowest levels of the Leen Sewer Outfall, and the sewage will be lifted, when all the works are completed, by means of a pair of engines from the lower gravitation outfall in the valley to the upper one leading to the farm.

The engines are of the beam type, are each of 40 horse-power nominal, but will probably indicate 100 horse-power. The pumps will be double-acting, on the bucket principle, with large areas and small lifts.

The sewage will be received into tanks and wells, and pass through straining pits and then be raised into a vertical iron cylinder, forming a cushion valve, or open air-vessel, where the natural head will be created in order to secure a due but variable discharge through the main into the outfall conduit.

The buildings are of brick and stone, and are substantial, with a taint of æsthetic pronunciation, and consist of an engine-house, boiler-house, coal stores, chimney, two engineers' lodges, and the usual appendages of a pumping establishment fitted for permanent and economic work.

Before giving a technical description of the farm, the author wishes to make some reference to two, in his mind, most important aspects of the sewage picture.

The first is the dealing with manufacturing refuse. In towns like Nottingham, also in towns similar to Leeds, Manchester, and Coventry, an immense quantity of water is used for bleaching, dyeing and detersive purposes, and a corresponding influx of fluid matter has to be treated, *nolentes volentes*, and in some way or other disposed of at the termination of the sewerage enterprise. Now these floods of liquids are in no sense sewage, they are simply disorganised waters, waters tinted by the various but beautiful hues which appertain to modern feminine costume, waters containing bleaching powder and soap, diluted frequently a hundred times by the purest springs that the earth is capable of yielding. These liquid floods should not be designated sewage, they destroy the whole *régime* when land is compelled to be resorted to for the reception for organic waste and they entail a public expenditure which is *very unfairly distributed.*

There is no doubt that the casting of solid matter into sewers, or solid refuse into rivers, can be prevented by the Rivers' Pollution Act, and other recent sanitary legislation; but there is a certain class of manufacturing waste which more or less insidiously finds its way, by various means, into the public sewers of a large town, and which produces deposit, creates stoppage and adds enormously to the difficulties which ever attend the disposal of sewage. The author has frequently found tons of sumach, whole sheepskins, shrubberies, tanning and brewery waste of a solid nature, offcast clothing, building refuse, and inanimate quadrupeds composedly occupying the inverts of a drainage system, mechanically well designed.

These, in a town like Nottingham, when augmented by carbonate of lime from marble and stone works, bundles of lace from the factories, clods of cotton waste and coherent hose from the machinery and hosing works, and dilapidated wares from forty thousand domiciles do not form suitable materials for ordinary irrigation, nor, if dissolved, would add much to the nitrogenic value of the sewage.

In old and large towns this mischief cannot altogether be well prevented, but more care should be taken, and firmness exhibited on the part of the authorities, to require all purely solid manufacturing waste to be arrested on the premises, and not indiscriminately allowed to gorge the sewers and trouble their proper contents.

As to liquid manufacturing refuse, there are many means of decolourising and otherwise purifying waters which have been necessarily employed in manufacturing industries. Sometimes subsidence, aided by simple and cheap agents, such as carbonate of lime, or sulphate of lime, alumina or iron, or common charcoal, or one of the many reactive salts, pure or combined, will render water, stained by dyes or laden with impurities (soluble or partially so), fairly admissible into a river or even a small stream, and, in my opinion, the manufacturing section of the community should be legally required to, at least, decently cleanse the water they obtain from the public water sources of their locality or from their adjacent rivers or private wells, before turning the same into the first available sewer.

The author has strong views on this subject, and when you are reminded that a brewer, or a maltster, or a dyer, or a bleacher, or any one engaged in a trade where water is a primal necessity, may at once multiply by twentyfold the volume of liquid to be dealt with at the selected outfall, it becomes a very serious question for the ratepayers of any district, be they rich or impecunious. As an example take a town, no matter where, of 20,000 inhabitants. The sewage volume, apart from manufacturing contributions, should not exceed 350 or 400,000 gallons daily. This volume may from one manufacturing centre alone be doubled, and speaking from information practically gained in many large towns, the sewage flow is frequently increased from 50 to 100 per cent., and correspondingly reduced in agricultural value by the enormous outpourings of even a single manufacturing establishment.

It may be said there are two sides to this question, and perhaps there are; that the wealth and well-being of a locality depend upon its special trades and industries, and that if the aggregate cost of disposing of waste products be comparatively excessive the whole local community should contribute. Having seen so much of this in the more populated centres, the author is quite of the opinion that the most wealthy manufacturers and more opulent citizens of an urban area do not contribute in an equitable ratio to the annual and increasingly heavy burdens imposed upon a ratepaying constituency for the luxury they enjoy in having their buildings of labour and mansions of ease placed and maintained on a platform of sanitary security.

The second aspect of the sewage question to be referred to, is the one affecting the separation of rain and sewage waters. The author has never advocated, as a principle, the rigid division of rain and sewage. It is impossible to effect this in any system of sewerage, large or small.

That rain should go to the rivers and sewage to the soil is a proposition that cannot be challenged, but the complicated conditions which arise and prevail, and always will, amongst the civilised bodies of humanity, prevent the tender demarcation line being exactly determined. Take a hypothetical area of country, a land consisting of, say 1000 acres, designed to be the site of a large and fairly populated town. At the present time suppose it to be in a virgin form, unbuilt upon, and uncontaminated by any of the results arising from the exigencies of modern life. Undoubtedly, in such a case, provide for the removal of rainfall, in its pure state, conserve it and use it as much as possible, but do not commingle it with the excretal refuse which men and animals alike, by nature produce—refuse, which applied according to the laws of nature, is regenerative and reproductive, but abused, is destructive to every form of existence. In a town like Nottingham it would be impossible, without the incurrence of expenditure which no one would for a moment listen to, to carry out an absolute separation of rain and sewage.

In the case of one line of outfall alone, a sewer two feet in diameter would convey the normal flow of sewage, but when heavy rain occurs, this outfall referred to, seven feet in diameter, is frequently insufficient to remove a flood. Moderate rainfall is, however, often beneficial as well to the contents of the sewers as to the sewers themselves.

It carries with it, especially in the earlier periods of its fall, a large amount of carbonaceous and nitrogenous matter, which is of high manurial value, and which would create great nuisance if discharged into a river. The author, therefore, has never proposed to divert light rainfall; but all rainfall exceeding one quarter of an inch in twenty-four hours I have treated as storm-water.

Such rainfall seldom occurs more than about thirty days in the year, and in Nottingham may be delivered into the Trent with impunity.

On this subject the late Royal Commission on the Pollution of Rivers remarks, that, "To provide for the exceptional occasions when excessive rainfall (or 'storm-water' as it is technically called) prevails, would entail in many cases an expenditure in sewerage works, many times greater than that necessary in ordinary weather," and that "however undesirable, it will be necessary to permit storm-water to flow directly into the rivers and streams without preliminary cleansing."

Lastly, as to the Sewage Farm. On the acquisition of the land, operations were at once commenced for the preparation of the soil, not only for the defecation of the sewage, but the realisation, if possible, of some pecuniary return. The land was in a poor and weak state, and doubtless on account of a kind of prescient understanding, not only on the part of the proprietors, but also of the tenants, that the land would be required and taken for public purposes, it was suffered to degrade in stamina and cultivation. Usually grain crops had been grown with a moderate proportion of roots and grass, but of course, the whole system of farming had to be specially altered and reconstituted to suit the special requirements of a newly established method of appropriating land to the service of modern British life.

The first works were the removal of unrequired fences and the improvement of those which were bound to be maintained. Several miles of old and uncultivated hedges were cancelled, but the main fences dividing the territorial lands were by agreement retained. Afterwards the whole estate of 640 acres was viewed as a sewage plain, and, whilst having in prospect good agricultural returns, it was felt that the first consideration was, the cleansing of the sewage at the lowest sensible rate.

New roads were designed, laid out, and made; these of course had reference to the rapid removal of produce, with the smallest spoliation of land.

Fortunately the land and the river Trent combined, produced any required quantity of gravel for the construction of the roads, and very efficient avenues of access and departure were provided. Also it happened that several railway stations were available, amongst them Burton Joyce and Carlton on the Midland, and Colwick and Gedling on the Great Northern lines of railway. From the former milk is sent daily to London, and from all stations, produce can be distributed in the local markets.

The principal works, however, were the drainage of the land, the construction of the carriers, the preparation of the irrigation surfaces, the erection of the farm buildings, and the establishment of a general policy of administration which should govern the undertaking, presently, and in the future. These points will be referred to *seriatim.*

The drainage was clearly the most important and essential work, and was carried out by the staff of the Corporation. Of the 640 acres assigned for sewage purposes, about 130 acres were drained in a very close manner, for so-called intermittent filtration, or intensified land irrigation. The residue of the estate was drained and prepared for so-called broad irrigation.

The drainage is now nearly completed, and all the carriers are formed. The lines of main drains extend from north to south, across the farm, and deliver into the stream or ditches, which circumflow the land, ultimately discharging of course into the river Trent. In the filtration area the main drains were laid two chains apart, with contributing pipes or weepers on the herring-bone plan, 10 feet apart. The former were 12 inches in diameter, of glazed earthenware pipes, and the latter of ordinary, but carefully made, red earthenware tubes, 4 inches and 3 inches internal bore. Only very short lengths of the extremities of the weeper drains were 3 inches in diameter.

In the residue, but larger portion of the farm, where the land was designed to be used for wider and more general purposes, the principal drains were placed 4 chains apart, and the lateral feeders (as in the other case, on the herring-bone plan) 20 feet apart.

All the main lines of drains were sunk as low as the carrying off dykes and rivers would allow, and range from 4 to 8 or 9 feet in depth, beneath the surface of the ground.

These main drains are parallel to each other, and are laid almost invariably in straight lines, and with true and uniform gradients from point to point, and in fact conform to the principles which should govern all properly constructed town sewerage. Manholes are built at all changes of direction or level, and the action of every portion of the drainage process can therefore be watched and governed, and, if necessary, modified or corrected from time to time.

A plan, showing the configuration and boundaries of the farm, also another showing the general drainage of the farm, are submitted to the meeting, together with one of the many sheets of sections, which exhibit the mode of arranging the gradients of the main underground drains.

A fair conception of the depths can be ascertained from the section sheet, and it will be observed that although the depths are great, the gradients are as a rule flat, and more so than one would personally select or determine had the physical conditions been different. Therefore arose the necessity of providing for a rapid means of inspection and flushing; but it should be said that, up to the present time, after six years of heavy work, there has been not the slightest occasion to resort to any purgative operations.

Referring again to the plans, you will observe that No. 1 is the Ordnance Plan of the borough and the surrounding districts; No. 2 is the outline or superficial plan of the farm and explains the general drainage features; No. 3 (a section) shows the characteristic features of the surface and drainage gradients, and the residue of the plans show constructive details of intercepting and outfall works, which may afford interest to some members of the Association. The larger or leading drains have butt joints as a rule, but a considerable portion of the filtration area was laid with socket joints; all the joints of the smaller or contributory drains were butt joints covered, in the first place, with loamy soil or turf, or both, and special pains were taken to keep the lines straight and the gradients true.

On the completion of the drainage the carriers were formed. These are simple in arrangement, and in material and in construction.

At the end of the outfall sewer the leading carrier commences. This, and all the carriers of the first and second order, were made of lias lime concrete. The main carrier is 7 feet wide at the top, and 5 feet wide at the bottom, the depth being 3 feet; the present length is about a mile, but the ultimate length is of course undeterminate. The smaller carriers vary in size, but have the same form of section.

Some are 6 feet wide at the top, and 4 feet at the bottom, and 3 feet deep; others are 5 feet wide at the top, and 3 feet at the bottom, and 2 feet 3 inches deep. The bottoms are all flat, the thickness of the concrete is generally 4½ to 5½ inches, none of the carriers are arched or covered over, but freely exposed to the air. All the concrete constructions are supported on embankments formed of earth and local gravel, with outer slopes of about two to one, and the whole are seeded, turfed, and planted.

The minor carriers are formed with the plough, and consist of grips or embankments, according to the contour of the land, and these are of course moveable, season by season, and subordinate to the nature of the intended crops, and the character of the tillage.

The sewage is controlled by means of oak sluices, paddles or gates, and the general intention has been to afford means of irrigating the whole farm area at one time, or to sectionise the land and distribute the sewage according to temporary wants. It has frequently been the practice to convey the sewage over farm lands through closed carriers of iron pipes; but this plan has been found to be not only expensive in first cost, but to entail heavy yearly expenditure in cleansing and repairs.

At many of the recently constructed sewage farms, both in this country and abroad, the system of open carriers has been adopted; and no form of construction, the author suggests, can be more effective and cheap than that which has been used at Stoke Bardolph. Here everything is exposed to view; the sewage suffers no material decomposition before it is applied to the land, and the materials for the carriers have been acquired at the lowest possible rate.

In the case of Stoke, the cement was obtained direct from the manufacturers, at the wholesale price, and the gravel was derived from the immediate land and neighbourhood. The preparation of the ground for the reception of the sewage was, in parts, somewhat expensive. The fields were generally level, and sometimes too level, and it became necessary to make artificial inclinations. Most of the work, however, was done by the plough, and hand labour was sparingly employed. One great object was to avoid the spoiling of the land by the removal of its natural earth covering, and the latter was therefore retained, *in loco naturæ*, as far as possible. For rye grass and the coarser crops, the land was divided into plains or areas, and simply treated on the wide ridge and furrow plan. For roots and succulent vegetables, narrow beds have been formed, and the sewage has been allowed to split up into innumerable dykes and passages, and to fertilise the roots of a vegetable world, annually recreated on the ridges of a naturally deposited soil, which has passed through the vicissitudes of perhaps a thousand years.

No difficulty has yet been experienced in the delivery of the sewage, and no nuisance has yet been created; of course, time will show what the land is capable of receiving, and how far the organic elements of the sewage can, with agricultural effect, be assimilated with a dry, sandy, and absorbent soil. If the sea-sand plains of Craigentinney and Lochend, the gravelly deposits of Genevilliers and St. Ouen, and the silicious and arid tracts of country which environ the human density of Berlin, will provide a solution of the sewage question, we may rely upon the Stoke meadows, as means of restoring local waste and building up chemical purity, if that expression can by a chemist be defined.

Fortunately, increased land space can be obtained, if wanted; and, in fact, the whole valley of the Trent for miles in area and distance would be greatly enhanced in value, if an inexpensive and careful distribution of discarded but potential products were capable of being applied to them.

As to the farm buildings, these have been somewhat expensive, but looking to the future, and to the general policy which has guided the Committee in the conduct of the farm, the outlays have not been in any degree excessive. A good and pleasant homestead existed, this has been enlarged and improved, and occupies a most eligible position at the south end of the farm, and almost immediately on the left bank of the Trent. Another farm-house with the usual appurtenant buildings existed at the west end of the land, and this has been and is occupied by the sub-manager or assistant.

Offices were built and the necessary business accommodation provided. At the south or administrative part of the farm, the stables, cowsheds, and other requisite buildings were erected.

There is now accommodation for about a hundred cows in daily milk, for about forty horses (which are employed on the land), and for pigs and other animals which altogether consume a large proportion of the vegetable products.

Sheds of large size, of wood, and with ventilating roofs of somewhat novel construction have been built, and these are appropriated to the culture of young and growing stock.

Several cottages were built for the labourers and their families employed upon the farm. These were found permanently necessary as labour was becoming comparatively dear, and it appeared a transparent duty to retain on the premises not only good but specially experienced servants.

Grain stores and workshops have also been erected, with dairy, breeding sheds, and the indispensable concomitants of a farm, designed for the production of stock, the conversion of locally grown produce into potatoes, cabbages, turnips, mangel wurzel, and other commercial and marketable materials, and the destruction of a nuisance as much universal as understood.

The farm manager (Mr. Avis), who is publicly known and much appreciated, has given his great and studiously acquired experience to this sewage farm undertaking, and not only his agricultural results, but the results which he has attained in the breeding of horses and stock, and in dealing with a complicated problem, should have prominent recognition.

As to the last point promised to be referred to, viz. the general policy of administration and above all the fundamental ground of action which the Nottingham Corporation have acted upon, and the ground also which I think should influence the action of other and future bodies, a few words may be said in concluding a somewhat lengthy and tedious discourse.

It is very difficult, at the present stage of the sewage question, to introduce much novelty or suggest departures new; for every one is supposed to be conversant with the minutest detail, and to be able to advise on the most competent means of extinguishing nuisance and creating municipal advantages in terms of health or money.

The world has been flooded with proposals and schemes for the disposal of the refuse, fæcal and otherwise, of our large towns and even of our sparsely populated country districts. The greatest city extant, with a population of upwards of four millions, still continues to cast its sewage into our finest English river, and to realise a diurnal reflux thereof into the midst of her population. Many large English towns, especially those in the north and west, have hardly moved in the direction of preserving their rivers from fæcal impurity. Some have spent enormous sums and only achieved a qualified success. Others have been contented with a timid outlay, and found at last the necessity of commencing afresh on entirely new principles.

A few sewerage authorities established by Parliament, notably the late "Lower Thames Valley Sewerage Board," which represented an important group of residential districts on the Thames, outside and above the Metropolitan area, have with their adversaries spent tens of thousands of pounds in strife and litigation and Government inquiries and experiments, and still remain *in statu quo*.

There are several exceptions, however, not only in this country but on the Continent, where the governing bodies, aided by the intelligent moral support of their interested and *rate-paying constituents*, have consistently and persistently pursued a broad, and wise, and expensive policy, and have reaped and will continue to enjoy the benefits of well-devised measures.

The primary object of all works of a hygienic nature is to raise the standard, physically, morally, and intellectually, of public health and happiness, and this cannot be accomplished without some corresponding expenditure. It is perfectly useless to demand large sanitary improvements, and expect the public purse to remain unmolested. This particularly applies to sewage operations, and those allied therewith.

Sewage has not been found to yield an income in alleviation of the rates, of either a small or a large town, and *never will*; and the more complicated the question is made, the more will be the annual deficit.

Also, whilst the compensatory value of sanitary labour and outlay is not capable of being accurately expressed in terms of money, there is always the danger of apathy, and even discontent, arising from the very success of the works undertaken, remembering that "Preventive measures are obnoxious to obloquy, for the more successful they are, the less apparent is the need of them."

These general remarks have some and somewhat strong reference to the enormous operations of sewage disposal which are being proceeded with on the Continent of Europe. Most of the large cities have been alive to the vital necessity of an improved mode of disposing of every kind of decomposable refuse.

Paris, perhaps, took the lead; Brussels followed; then the German towns, Dantzic, Frankfort, Breslau, Munich, and Berlin commenced in thorough earnestness and on scientific lines.

Afterwards Italy began to move, and even Holland was roused into sanitary existence.

There will always be differences of opinion as to the method of farming any land; but where sewage farming is concerned, opinions are both prolific and bewildering. Some would drown the land with sewage and foreign waters, regardless of any consequences of either a sanitary or pecuniary nature; the object in this case being to bury the sewage in the least possible time; others would go to the opposite pole and work out an elaborate manipulation, with excessive land area and corresponding annual taxation.

The author's own experience has been gained from a careful study of most of the sewage farms of Italy and Spain; and his personal conviction is, that the whole matter may be wrapt up in a simple equation: given, certain earth products capable of producing milk, meat, and corresponding food, the animals which are the media of transformation should stock the farm, and be accurately subject, in quality and quantity, to the food-producing power.

In all farms, nevertheless, there are specialties; and, as in Paris and Berlin, particular vegetables, fruits, and even flowers, may be grown with advantage, supplementary to the grosser produce.

There is no doubt that in this serious subject (taken at large), a great deal has yet to be learnt, a great deal yet to be taught; the details are numerous and the prejudices are extensive, but I think we may and ought, in public fairness, to proclaim in the words of the accomplished old Terence,—

> "Homo sum: humani nihil a me alienum puto."

A vote of thanks to Mr. Tarbotton for his valuable paper was proposed by the President and carried unanimously.

DISCUSSION.

Mr. Gordon: I am only sorry we are so limited in the time at our disposal to-day for the discussion of this paper. Therefore, in attempting to open the discussion, I shall have to confine myself practically to only putting questions to Mr. Tarbotton, with a view of eliciting still further information from that gentleman which I think will be of value to our Association. The first point is one which appears to be of importance. Mr. Tarbotton tells us that, under the provisions of a Local Act, he has been enabled to fix the levels of all future buildings in Nottingham above flood-level. Will he kindly explain whether by that he means the ground floor level of the house, or has he power to prohibit the construction of any cellar below the flood-level? If he has, it is a provision which I believe is very exceptional elsewhere. We have at Leicester power to prohibit cellars where they are below the level of the floods or are liable to flooding from street drainage, and it is a very valuable provision where towns are liable to flooded streets and cellars. Mr. Tarbotton also tells us, that there is a small river called the Beck, which is now culverted over and forms a combined river and sewer. It would be extremely valuable, in dealing with other cases of a similar kind, if Mr. Tarbotton would tell us, if he can, the amount of rainfall which the covered part of a culvert of that kind provides for. It would be a guide in other cases, and it is well to know what is being done in towns like Nottingham. Mr. Tarbotton has given us the sizes of subsidiary sewers, and tells us distinctly—and I quite agree with him—that it is next to impossible to carry out the separate system, as commonly understood, and therefore he has never created a separate system to the extent that some gentlemen have advocated. I know that, by the separate system you may exclude a very large amount of rainfall from the sewers, but you cannot possibly exclude it all from the sewers that take house drainage. I have had to deal with this question very largely recently, and have had to investigate the amount of rainfall it is possible to extract from sewers taking sewage from houses by the separate system. I quite agree with the opinion expressed by Mr. Tarbotton on that subject, that it is not possible to extract so large an amount of the rainfall as is commonly supposed; but if Mr. Tarbotton will kindly tells us what amount of rainfall he has allowed for in the sewers which he has described in his paper, I should be exceedingly obliged. I have to deal with the question, and others have to deal with it, and I have no doubt there is great diversity of opinion in the minds of many members of the Association on this point. Mr. Tarbotton tells us also that the claims for compensation have been very large, and we know that is so in cases of this kind. If we had had particulars as to the amount per lineal or square yard, it would have been very valuable information. Mr. Tarbotton has not told you anything about the pail system at Nottingham, or whether it has lessened the difficulty of dealing with the sewage. I believe there is a mistaken notion on that point; I do not believe that it lessens the difficulty at all. I notice 640 acres are provided for the disposal of the sewage of Nottingham, at the high rental of 5*l.* per acre. I do not know whether Mr. Tarbotton considers that quantity of land sufficient for a town of the size of Nottingham, but I think for so large a town it will hardly be found sufficient. I should also have been glad if this paper had contained information as to the cost of draining and laying out the land, and also the cost of the main outfall sewers. All these are things which concern us individually as members of the Association who have to carry out similar works. Therefore, if Mr. Tarbotton can add, either now or hereafter, information of the kind I have asked for, I am sure it would be exceedingly valuable. The cost of the drainage works generally at Nottingham would also have been of great service. Justice cannot be done to this paper, of that I am quite sure, within the limits of the time we have at our disposal for its discussion to-day.

Mr. VAWSER: It would be quite impossible for any one to discuss this paper in the five minutes to which each speaker is limited; and therefore we shall not be able to discuss it in very great detail to-day. The paper is an exceedingly valuable one, and will bear reading again, and we shall gather a great deal of information from it, which we overlooked during the reading. There are several things I should like to have mentioned, especially as I received my early professional training at Nottingham, and had the privilege of commencing my career under Mr. Tarbotton, and learned under him a good part of the little I know; I therefore feel considerable interest in anything that relates to Nottingham. One thing which occurs to me is that however elaborately the works are described on paper, it would be much better if we could actually see the works. I should like to hear something further with respect to the discharge of water from manufactories into the sewers; so far as I know, there is nothing to prevent a manufacturer turning liquid manufactory refuse into the sewers, provided it does not create a nuisance or cause injury to the sewers, or in some way or other prevent the sewage being purified. Mr. Tarbotton mentions that this discharge of refuse has not yet become general in Nottingham, but he speaks of it as likely to be a serious matter in the future. For my own part I do not think the difficulty with manufactory waste liquids ever can become serious, because the riparian owners on the various streams will take steps to prevent a large volume of water being diverted from the streams into the sewers. If all the water more or less polluted or tainted by manufacturing processes were turned from the brooks into the sewers, the brooks themselves would become dry, and the value of the sites for manufacturing purposes would be deteriorated. At the same time, it is a point Mr. Tarbotton has thought a good deal about, and evidently has a strong opinion upon.

Mr. Ellice-Clark: The value of the paper would have been materially increased if some units of cost and data relating to rainfall reaching the sewers had been given. The observations at Nottingham, in this respect, have been carefully made, and the results would be of great value to municipal engineers. It is well known that the ordinary rainfall, say half an inch in twenty-four hours, does not govern the capacity of sewers; what are denominated "heavy falls in short periods" are the prime factors for the capacity of sewers which cannot be relieved immediately.

It would be particularly interesting to have particulars of the Nottingham observations for—

(*a*) The quantity of rain water reaching the sewers, from actual gauging during an ascertained heavy fall in a short period.

(*b*) Density of buildings in the area draining into the gauged sewer.

(*c*) General imporosity of the area, taking into consideration paved streets, back yards, open spaces, &c.

(*d*) Gradients of the area.

(*e*) Provision made to relieve the sewers during such heavy falls.

It may be interesting to know that at Hove as much as $\frac{3}{4}$ of an inch of rain has fallen in twenty minutes, and as far as could be ascertained ·75 of the registered fall has reached the sewers.

Mr. Fowler: May I ask whether it is the intention to still scavenge at both ends of the sewers when the scheme is developed? We know that, at Nottingham, they have a very elaborate and expensive system of collecting soil and filth throughout the town, and, when this scheme is developed, they will also have very elaborate means of dealing with the liquid sewage at the outfall. Now does it not look absurd to have all the labour and cost of dealing with the collection and disposal of this filth—work which is not fit for slaves or workmen in a civilized country—when they are going to deal with the other portion, the liquid sewage, by irrigation? My view is, if you have to spend money for an elaborate scheme like this, you should discharge the whole of the sewage into the outfall and there deal with it. I should like to know what the discharge is, and the capacity of the sewers. I found in the large sewers which I carried out in Leeds, to take a day's rainfall was fallacious. It might rain steadily for a week, but that did not affect the sewers in Leeds injuriously, but if I had a thunderstorm of half-an-hour (although it was only a small portion of the rainfall which would fall in a week), my sewers would be flooded and inundated. Now, I contend, in designing a system of sewerage, you should design it to take the rainfall which may occur in a quarter of a hour or so. If you take a quarter of an inch to fall in twenty-four hours and that amount is divided into sectional portions of twenty-four hours, the amounts to ·10 per hour of rainfall. That does not affect the sewers in the slightest. Therefore one would like a little information on this point. I know it is the rule not to ask for too much, not to ask for a formula from a professional gentleman like Mr. Tarbotton, because, when professional men like him read papers, we should not seek for special information gratis. The Institute of Civil Engineers is very careful in discussing papers, not to extract professional opinions from their authors free of cost. Questions are put as carefully and circumspectly as possible, and if they are answered all the better for us. If Mr. Tarbotton could answer the question I have put, without detriment to himself, I should be obliged. With regard to culverting over brooks, as engineer to the Corporation of Leeds, I expended about 40,000*l.* in improving the streams there. Our friend Sir Robert Rawlinson was down at the time, and gave us a word of caution (I was a young man at that time) to be very careful not to cover over the streams, because of the immense rainfall that sometimes occurs. There are only recent records of extensive floods. We cannot go back for even half a century, and therefore, there is but little information to be obtained as to the rain which may fall in an hour or so. It is much to be regretted that we have no reliable information as to the quantity of rain which will fall in a limited space of time, and therefore those about to cover over streams should be careful, otherwise they may cause very serious mischief. Therefore, following out Sir Robert Rawlinson's view, I would ask if these brooks converted into sewers have been carefully considered as to the amount of rainfall they will take as sewers?

Mr. A. T. DAVIS: May I be allowed to ask Mr. Tarbotton whether he would give us some idea of the quality of the effluent he obtains from the sewage farm with drains so close as from 10 to 20 feet apart?

A MEMBER: I will not occupy much time, because the principal points I had jotted down have been referred to by other speakers; but there is one thing occurred to me which I consider important in connection with this very interesting paper. It is the ventilation of sewers, concerning which Mr. Tarbotton says, "Summits are attained by carrying up iron shafts to the nearest and most convenient buildings." The ventilation of sewers with steep gradients is very difficult with only street gratings, and shafts are a proper and suitable arrangement where buildings of any description can be obtained to support the shaft; but, in my experience, owners of property always raise a difficulty, and say "Oh no, we are not going to have your stink shaft placed opposite our houses," and you cannot remove the prejudice from their minds. Of course there is no power by which we can compel them to allow the shafts to be fixed, and I presume that at

Nottingham it is only obtained by the persuasive influence brought to bear on the owners of property. I should like to know whether Mr. Tarbotton has got many of these shafts fixed, because there is no doubt they overcome a great difficulty in connection with the ventilation of sewers, and the nearer you approximate to the separate system, the greater the difficulty becomes of ventilating the sewers.

Mr. Stainthorpe : Has Mr. Tarbotton had any great difficulty with property owners, in getting ventilating shafts fixed against their premises ?

The President : For my own part I shall make no attempt to go into the details of Mr. Tarbotton's paper now, but shall study it at my leisure, and, if possible, resume the discussion of it at our next annual meeting. My impression is, that course would have most beneficial results, and I hope Mr. Tarbotton will be with us next year. I think the paper he has read, so full of information and so full of matters we are all interested in, will bear a whole year's consideration. I will not take up further time now, but at once ask Mr. Tarbotton to reply to the observations made.

Mr. Tarbotton : I should have liked to have had more time than you can allow me to reply to the questions which have been submitted to me. I will, however, supplement this paper, if it be your desire that I should do so, by information which will cover many of the points more fully than I can reply to them at the present moment. At the same time, I will just make a few remarks, which may to a certain extent satisfy your minds. My friend Mr. Gordon referred, in the first instance, to the question of the flood level. I can simply answer that question, and it is a very important one, by saying that a large portion of the southern part of Nottingham is subject to floods, and when the water rises in the Trent, which it frequently has done to the extent of twelve feet in two days, with much less than an inch of rainfall, a large amount of property was subjected to enormous damage. A water level of the highest flood was determined, and it was made imperative that not even basements or privies or backyards should be constructed below the flood-level, and this was distinctly settled and was strictly enforced; that level has proved a successful one, and we have had no flooding in the district since it was adopted. With regard to the river Beck, I desire to make a few remarks respecting the covering over of the stream and the amount of water to be provided for. The river Beck, as is the case in many towns—like the Fleet in London, and streams of that nature in other large towns—was indifferently covered over from point to point by all kinds of authorities. Some gentlemen here present, perhaps, do not remember the great investigation which took place in 1845, under the General Commission which traversed the country. At that time Mr. Hawkesley was engineer to a number of works and lived in Nottingham, and he made some special remarks on this particular river Beck, which he showed, scientifically and mathematically, had been dealt with, most improperly. It had been covered over by different authorities, and no rainfall had been provided for. It consequently became a main sewer, and of course became gorged and has burst from time to time, and the enormous work of the flood-water system described in my paper has been made only within the last two years. This work alone, to remedy the unfortunate state of that river, has cost 50,000*l.*, independently of any sewerage operations. The mean rainfall provided for has been asked for. I have always, as a general principle, provided for a quarter of an inch rainfall in twenty-four hours. You cannot compare one town with another on parallel lines. The gradients, the levels, and other conditions vary so enormously, that you cannot lay down an absolute maximum or rule for the disposition of rainfall. I have found, as a general principle, that a quarter of an inch rainfall in twenty-four hours ought properly to be provided for. But in Nottingham we could not do this, by reason of the contour of the ground, and therefore the rainfall is dealt with as storm water and carried into the nearest outlet or river. With regard to claims for compensation, I have found no rule that can be laid down with regard to them. I have had cases in all parts of England, and I think the most expensive have been in Liverpool. The most costly we have had in Nottingham, for easement only, in passing through private property, have averaged from 15*s.* to 20*s.* per yard. With regard to the pail system, referred to by Mr. Fowler, I am no advocate of the pail system, and I never have been. I have always been opposed to it. I believe it was first tried at Rochdale, and it grew in popular favour with certain sanitary authorities; but in Nottingham I have consistently denounced it from the very first. We have spent I should think 100,000*l.* on the system of pail refuse removing. I do not say at all that it is a failure, but I do say this, that if there were a severe frost, a strike of the work-people, or if sundry other things occurred, we should have an enormous public nuisance, which would be a disgrace to the town. With regard to the cost of the outfall sewer units, I will, if I can, shortly give these. The cost of the intercepting sewer — the Leen valley sewer described—was 50,000*l.* at least. The cost of the whole undertaking, that is the outfall sewer and the laying out of the farm, of course exclusive of the rent, has been 160,000*l.* The cost of the outfall sewer has been about 7000*l.* per mile, and as it is five miles long the total has been about 35,000*l.* The cost of the pumping station, now approaching completion, will be about 25,000*l.* These two figures made 60,000*l.*, and the laying out of the connecting sewers brings that amount up to something like 120,000*l.* The cost of laying out the farm of 650 acres of land, including trenching as shown on the plan, carriers, preparing the ground for planting and sundry expenses, has amounted to something like 40,000*l.* I think we have now got nearly to the end of our expenditure. Of course there are "incidentals," but undoubtedly 10,000*l.* to 15,000*l.* will cover all these. With regard to a formula for rainfall, it has been the one I think universally adopted by mathematicians with regard to discharge in outfall sewers. Of course the hydraulic mean depth governs the potential value of the flow; but, as I have said before, I have never calculated for beyond a quarter of an inch rainfall over the ordinary sewage, which should not exceed in a town like Nottingham, or a town like Hanley, 22 gallons per head per day. As to manufacturing refuse, which Mr. Vawser has referred to, I have expressed, I think, perhaps a strong opinion in my paper. In a case like Nottingham, or Salford, or Manchester, if the manufacturing refuse is eliminated from the streams and brooks, and then turned into the sewers, at the end of the valley you would have no water at all. If we have to deal with every ounce of liquid which everybody on the course of the stream chooses to take out and use, and then turn it into our sewers, all I can say is this, you must make your sewers vastly larger, and really covered rivers. That is perfectly manifest. With regard to the ventilation of the summits of our sewers, I have had no special difficulty about that. My practice has been to place perfectly open ventilators about 100 yards apart; but in steep districts I have had to adopt other means. In those cases we carry up pipes by the side of the nearest house for which we can gain assent. I will give you a case which occurred only a few hours ago. I wrote to the agent for the estate of Lord Manvers, asking for permission to put up ventilating pipes on his property, perfectly apart from his own house, and he instantaneously gave his consent, without the slightest restriction or terms of easement. I think when people are approached properly, and when the matter is fully explained to them, unless the parties are altogether unreasonable, there is never any difficulty in getting the required consent. With regard to the effluent water it has been analysed by Dr. Frankland, Dr. Wanklyn and others, and it has come out purer than the average Thames water supplied to London. I do not mean to say for a moment that it will always continue so, or that it is so at all times of the day; but these samples have been taken at different periods, quite without my own knowledge or sanction, and the results have been extremely satisfactory. In fact the effluent water is better than the water in the land before it was touched for sewage purposes. I hope to be able to give you further information on these various points some other time, and to supplement what I have said, but the remarks in the latter part of the paper will, I think, express my personal views on the general subject.

THE PRESENT ASPECT OF THE RURAL ROAD QUESTION, WITH SOME REMARKS ON THE MAINTENANCE OF MACADAMISED ROADS.

By E. B. ELLICE-CLARK, M.Inst.C.E., County Surveyor for Sussex (West).

Preliminary.

The scope of this paper has been purposely limited to the maintenance of rural roadways. Urban districts, as a rule, maintain highways in a fairly satisfactory manner, and where this is not so, it cannot be from the want of proper machinery to effect the object sought, but rather that the ratepayers do not demand a higher efficiency of maintenance, from supposed economical reasons—though it is highly probable that efficiency of maintenance and cost are in the inverse ratio, by which is meant that a road with a heavy vehicular traffic, if maintained so as to present as few traction obstacles as possible, will cost less than the same road, having the same burdens to carry, maintained so as to present great and numerous obstacles to traction. The case of Cheapside may be cited to prove this:—

Cheapside has a traffic unequalled by that of any other street in the world; it therefore presents greater difficulties of maintenance in the mere physical placing *in situ* of the materials, than a street with lesser traffic, and if its surface were full of depressions, projections, or longitudinal fissures, there would be some excuse for such a state of things, and the cost of maintenance might be expected to be greater than that of other streets accordingly; but it is not so. If the cost is reduced to the unit expressed by 100,000 tons burden borne by every yard in width of the street between the kerbs, in each year, Cheapside costs 1*s.* 1·7*d.*, while many macadamised streets of much less traffic and of greater width have been known to cost 4*s.* 8*d.* for the same unit, of which it may be said that they are never in a state of efficient repair; for while they are undergoing the process of repair, they are more out of repair than before repairs commenced, and the process of dissolution begins at one end of a long street before the reparation is complete at the other end. In the case of suburban and rural roads, the result may be practically summed up by saying, that badly maintained roads cost more to maintain than roads maintained in a state of high efficiency, and it would be well if ratepayers' representatives and road surveyors had this axiom constantly brought before them, for it is the one great weapon upon which reliance may be placed, as the only means of obtaining reform in road maintenance from the present constituted authorities.

Law relating to Maintenance or Upkeep.

By the common law of England, the highways of the country have to be maintained by the inhabitants at large, except in a few isolated instances which are so infrequent, that they may be eliminated as unimportant and not affecting the general law of the land. It is true that up to within a brief period, a large proportion of the principal roads coming within the scope of this paper, were maintained by trustees, as turnpike roads. The principle of maintaining roads by their users has, however, fallen into desuetude and will form the subject of inquiry during the course of this discussion. The present are the

Responsible Road Authorities.

Boroughs.
Local Boards—Urban and Rural.
Single parishes without Local Boards.
Grouped parishes formed into Highway Boards.
Moribund road trustees.
County Justices in Quarter Sessions.
Imperial Government.

Administration.

The theory, and to a great extent the practice of the maintenance of roads by Boroughs and local Boards does not leave much to be desired outside the Metropolis. Committees for highways have under them professional men and the roads are, as a rule, fairly maintained. Such, however, cannot be said of the single parishes having no local Boards. In these places, the surveyor is nominated by the vestry and is generally a farmer whose knowledge of roadmaking extends to the mere spreading of stones, broken or unbroken, as suits his humour, on the surface of the road at periods, not at regular intervals, nor when the road most needs repair, nor when the weather is most favourable, nor using the most suitable materials.

All these important considerations are pushed on one side for the convenience of employing local team labour. When the farmer-surveyor and also his fellow farmers have no other work for their horses, or when they cannot get on their land, then work is provided for the teams on the parish highways. In Sussex during the past year roads were repaired during the driest months, and in one parish the highways were not only repaired during a long continued period of dry weather, but were badly repaired, if such a term is applicable to the spreading of large unbroken stones on a hard surface; some of the stones weighing 10 lbs. each.

Of highway Boards it may be said, that like local Boards, they should provide the proper machinery of a qualified, professional road surveyor, and if the roads in such a district are not efficiently maintained it is generally the fault of those who "rule the roost" and pander to a cry of false economy. The part played in the larger area of the counties by the Justices in Quarter Sessions, is to grant subsidies to local authorities for the maintenance of such roads as they deem main roads, forming continuous routes between considerable towns. These subsidies are granted on the certificate of the County Surveyor that the roads are in a state of efficient repair.* It is clear that this divided jurisdiction and intermixing of areas and local authorities, with Imperial authorities and different forms of administrating the law, is productive of bad results, and the condition of roads is largely left to individuals who are responsible only to themselves, or to those who are in sympathy with them.

Incidence of Maintenance Cost.

From the accounts published by county Justices it is difficult to form any opinion on the comparative cost of the upkeep of roads under different authorities. The cost being given at per mile, without further data on which to form an opinion, it is obvious that the maintenance of a wide, level road, open to the weather, with little traffic, must be much less than that of a narrow road of steep, and numerous changes of gradient, with an equal traffic, so that when we find a main road in one parish costs 40*l.* per mile to maintain and another costs 400*l.*, there is little to be gained by discussing the figures given in county returns, and we must rely upon general observation.

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* Imperial taxation now contributes about one-fourth of the cost of the maintenance of such main roads by an annual grant of Parliament which, however, not being regulated by Statute may at any time be discontinued if the exigencies of the Chancellor of the Exchequer require the money for other purposes.

When each parish maintains its roadways and the surveyor is his own master, being an unpaid official, it is not in human nature that he should give that attention to the work which its necessities demand, nor is he possessed of the technical skill to carry out successfully, even so simple a duty as the repair of a road, and for these as well as the reasons given previously, parish roads cost more for upkeep than roads under the supervision of highway Boards, but here, in a lesser degree it must be admitted, the same objections apply. Farmers, forming a large majority of the members of such Boards, have much deference paid to them by surveyors, who, as a rule, are insufficiently paid and consequently do insufficient and inefficient work, and whose situations are held by so slight a thread that the least show of independence is considered to be insubordination, and visited with penalties accordingly.

So that most of the evils attendant upon the parochial system are inherent in the highway Board system; in the former they are intensified to such an extent as to be a grave blot on the internal administration of the country.

Existing Authorities, and Laws relating thereto.

The dissolution of road trustees has been taking place for many years; the universal outcry against tolls and the collection of the maintenance cost of the roads by road users, led Parliament to abolish turnpikes; these roads consequently fell into the hands of the parishes, and it soon became evident, that where formerly the roads were maintained in a highly satisfactory condition, they now rapidly deteriorated and in many cases had lapsed into as bad a condition as they were a century ago, before road trustees were initiated. The parochial system utterly broke down under the new state of things. As trusts were abolished, the area of dissatisfaction spread and grew to so large an extent, that without exaggeration it may be fairly said that the highways of rural England, which for a century had been the finest in the world, were fast becoming unusable. Parliament then stepped in with the Highways and Locomotives (Amendment) Act, by which roads disturnpiked since 1870, and main roads connecting together considerable towns, might be partly maintained at the expense of the county. Whether such a principle is sound from a political economist's view, is an open question; though, apart from securing more efficient maintenance—which to a certain extent it does—the measure recognises for the first time two important features:—

1. The breakdown of the parochial system of repair.
2. The necessity of distributing the maintenance cost of rural roads amongst urban and rural ratepayers, the presumption being that the rural districts would be relieved at the expense of the towns.

Seven years' working of the Act has proved the contrary. For many roads in urban districts, coming within the scope of the Act, are maintained at a higher cost to the county than the contribution to the county funds from such urban district. The inequalities of this Act, the cumbersome machinery it provides, and its limited scope, restricted to about one-tenth of the highways in the country, were soon amply demonstrated. The Legislature again interposed, and an annual grant is now contributed from Imperial taxation, to the extent of one-half of the sum contributed by the county, as a measure of relief to those rural communities whose grouping with the towns had been confidently expected would have relieved them of the heavy burdens they succeeded to on the lapse of the road tolls. This branch of the subject is worth much discussion, as a remedy for the existing evils is more likely to be found in the adjustment of the law relating to maintenance cost than in the practice of road repair.

The Highways and Locomotives Act a failure.

It will be observed from what has been said, that no less than six authorities, extending from the Imperial Legislature to the parish vestry, are interested, and have a voice in the repair of rural main roads. Instead of Parliament looking at this simple question in a simple manner, it would hardly be possible to devise a more complicated arrangement than has been set up by recent legislation. The Act of 1878 was hardly printed before difficulties arose. On the construction of the word "maintenance," every county has differed. In an able paper by Mr. Lobley, Borough Engineer of Hanley, he enunciates maintenance thus:—

1. Ordinary repairs to the surfaces of paved and macadamised carriage-ways.
2. Extraordinary repairs, such as putting in a good foundation for the pavement or macadam, or using new setts.
3. Scavenging or street-sweeping.
4. Watering.
5. Ordinary repairs to kerbs and channels.
6. Extraordinary repairs to the same, such as the substitution of new material for old.
7. Ordinary repairs to side footpaths.
8. New pavements to side footpaths.

To the foregoing may be added:—

9. Capital outlay for the substitution of paving for macadamising.
10. Proportions to be paid for the cost of scavenging and watering.
11. Cost of under drainage works.
12. Cost of supervision and establishment charges.

Difficulties of Administration under Existing Law.

It would be impracticable in this paper to enter into the detail of the various ways in which these difficulties have been dealt with. Within the writer's knowledge, independent divisions of the same county, interpret the word maintenance in such totally different ways that it would be difficult to recognise the executives are working the same Act.

Not the least of the difficulties encountered in working the Act is that of accounts. A special form of account has to be kept under the provisions of the Act, by which every hour a man is employed on a main road must be entered, every load of materials, the quantity of water and the team labour all have to be separately entered and charged to the main road account. The writer is Surveyor to a town having 28 miles of roads, and about 1½ miles of main roads. The work of maintaining the main road is inseparably mixed up with the maintenance of the other roads. Workmen pass without knowing it from ordinary roads to the main road. Machine sweepers and water-carts do the same thing, a load of water may be half distributed on a main road, and half on an ordinary road. In towns employing a large number of water-carts, say 30, it is impracticable to sever the work. A main road requires a separate staff, separate carts, separate foremen, separate supervision, to keep the accounts with anything like accuracy, and if a main road is of insufficient length to provide this separate administration economically, the cost of book-keeping and dividing the cost of maintenance will amount to a large percentage upon the cost of maintenance, and the writer ventures to express the opinion that such an accurate subdivision of accounts as the Act contemplates is nowhere kept, a great many of the items are arrived at but approximately. The same objections apply to the system in rural districts, where there is no clerical staff provided to do the work. The unpaid surveyors of parishes are frequently unable, from want of staff, to keep the complicated accounts, which require such minute division; and instances are not wanting where the unpaid surveyor of a parish has had to pay 30*l.* out of his own pocket during his year of office to have the accounts put into such a shape as would satisfy the Government auditor. It will be readily understood that these unpaid officials have not much zeal in having the roads properly maintained, as the less work done on the roads, the less book-keeping, and this has no doubt had a good deal to do with the decadence of main roads.

Here then we have the existing principle of the maintenance of highways by parishes, clearly proved to be faulty, and inflicting great hardships upon rural communities; focussed into a positive injustice upon individual ratepayers—as for instance, upon mill-owners, whose imports and exports are performed on railways, the maintenance cost of the transit-way they pay in railway rates, while brewers and millers, who use the highways very largely, have the greater portion of the maintenance cost of the transit-way paid for them by other people. These anomalies are eased down to a limited extent by the main roads system, but the complications in administering the Act have now built up such a feeling against the law that a remedy must be found.

Suggested Remedy.

A simple, safe, and effective remedy can be obtained by grappling boldly with the subject. Sweep away all distinctions between disturnpike roads, roads connecting large towns, and county or parish roads, and let all roads that are now repairable by the inhabitants at large, be repaired by a single authority. Adopting the county or division of a county as the unit of area. As an arbitrary line must be drawn somewhere between the rural and urban districts, fix a principle of demarcation, and exclude all towns of 10,000 inhabitants from the cost of a contribution to the county roads. There is a good reason for adopting this unit, inasmuch as the traffic in towns is a different class of traffic, and the upkeep of roads is performed in a different way. There is precedent for the principle, as the county police establishments are now maintained much on the lines of the above proposal for roads.

County Government and Road Repairs.

The present system of county government is, however, not calculated to give the impression that so great a change from complexity to simplicity could be brought about without representative county government. As a county surveyor, it is necessary for the writer to speak with that moderation which caution suggests. It is doubtful if the Justices who now govern counties by the cumbersome machinery of Quarter Sessions, would have additional responsibility thrown upon them without a complete change in the administration of county affairs. Perhaps no body of men in England do their work at less cost than county Justices. The great complaint is that they do so little, being an unrepresentative body. Parliament has not hitherto invested them with great powers or entrusted to their management such important affairs as are administered by municipal Corporations, and without doubt the fact that they are not subject to periodical election or rejection, has serious conscientious effects upon many Justices, who would be willing to deal with county funds in a more liberal spirit, and enter into increased responsibilities were they an elected body, having the sanction and support of ratepayers. In a word, country, or if the term is unsuitable, county roads cannot be efficiently maintained without a complete change in county government. Presuming such a change, and an elected board superseding the present Justices, a scheme something on the lines of the following should be administered in the highways department.

Board for the whole or divisions of a county, having a chief engineer. The area of the county or divisions, subdivided into districts, which might be determined by (*a*) Watershed considerations, or (*b*) Facilities for access by railway, or (*c*) Density of population (i. e. proximity to large towns).

Each district to have its surveyor or inspector, acting under the orders of his chief, who would be responsible to the Board, with the sewerage and other matters that do not touch the present discussion, and roads under his immediate charge.

District committees would be necessary, so as to meet not less than once a month, to whom the inspector would report, the county Board and district committees acting like town councils and other committees.

All contracts for materials and labour, manual and team, all appointments and dismissal of officers, would rest with the county Board, who would have under its charge every road now maintained by the inhabitants at large.

We should thus have (1) trained men, as paid officials, devoting their whole time to the duties of their office, directly responsible for the proper and economical upkeep of the roads. (2) A standard of efficient maintenance for the whole county would be set up, for which the Board would hold the chief engineer responsible; the divisional inspector would set up this standard of efficiency at comparative costs, for the books should show at a glance what a unit of roadway was costing in each division. This change of the administration would do more to effect a reform in road maintenance, than any attempt to patch up what is now considered to be an obsolete and effete system.

PRACTICE OF ROAD REPAIR.

Supervision.

In the first part of the paper allusion has been made to those who have entrusted to them the repairs of roads; it is only necessary to emphasise the contention that the existing system is costly and inadequate, and that roads should be supervised by competent persons, who should be paid for their work and be responsible to a highway committee.

Maintenance.

Original Defective Construction.—Excepting the main roads of this country most of the existing country highways were never properly constructed. The routes they follow are the last routes taken by travellers to get on hard ground from the sloughs into which the tracks were made. Formerly no attempt was made to build a road. The traffic passed over a beaten track and in the winter diverged right and left, to get out of mud. This accounts for the singular way in which many existing roads turn and twist, in an apparently inexplicable manner. After the turnpike roads were constructed by engineers, parish surveyors gradually followed, by making an attempt to "make" the parish roads. This consisted of throwing broken stones on to the trackway, and in the course of the last century this process has been added to by surface draining and a little cleansing, so that the highways have assumed the semblance of formed and shaped-up roads. The bottoms are, however, composed of soft stuff, and if the coating of metal is not put on in time, the roads become a mud track. It is too late to preach for the reconstruction of these roads from their foundations. It is impracticable to do anything but maintain them in sufficient repair. In such cases as this, it is necessary to under drain the roads with pipes with open joints, and the frequency of these will be necessary, according to the saturation of the soil. If the subsoil is wet, it will be impossible to maintain a good surface to a road. Surface drainage is of equal importance. Snow, rain, and frost are "sore destroyers" of roads. Side ditches or long water channels are indispensable to the preservation of good surfaces.

Transverse Section.

Much diversity of opinion exists amongst surveyors as to the cross section or contour of roads. In some counties, roads are "hog-backed" to such an extent that vehicles cannot pass over them with safety, except in the centre; the converse of this is found in leaving a road with a level transverse section, so much out of repair, that it becomes concave instead of being convex. It is obvious that if the versed sine of the section is too great, vehicles will follow the same track, viz. the crown of the road, which soon becomes worn out, while if water is allowed to remain in the road, it will be destroyed by the weather. From long experience the author has come to the conclusion that. the proper fall for roads repaired with flints or similar material is 1 in 24 from the centre, with broken granite 1 in 36. The intermediate gradients between these two are those suitable for materials that are harder than flints and softer than granite, as for instance, hard mountain limestone, which will take its place at about 1 in 30. "Barrelling" a road is a mere excuse for not keeping the surface in proper repair.

Materials.

Quality.—In nearly every English county good materials for road-making may be found, but where soft material like sandstone only is to be obtained locally, it will be found economical in most cases to obtain harder stone or granite from a distance than to repair the roads with unsuitable material.

Size or Weight.—Some difference of opinion exists as to the sizes to which stone should be reduced for metalling a road. There is a prevailing opinion that all stones should be broken to pass a gauge of 1½ inches: the writer ventures to express the opinion that this is an error. All the hardest stone, like granite, trap rock, basalt, the Devonshire dolerite and similar rocks, should be broken to a smaller gauge than flints and the hardest limestone, which in their turn should be broken smaller than such materials as Kentish rag and stones of a similar character. The method of specifying the dimensions of stone should be abandoned for a weight test. Macadam says, "Every piece of stone put on to a road which exceeds an inch in any of its dimensions is mischievous," and in most of his specifications he insists on no stone weighing more than six ounces. Parnell adopts 2½ inches for the largest dimensions. To within the past few years the latter size was very generally adopted, irrespective of the quality of the material. It has been the practice now for upwards of half a century when repairing roads with granite and the harder rocks, to have the stones broken as uniformly as possible. The results of this are that though the general surface may be in good repair, the road will be full of small rises and depressions, the surfaces of which are also rough, stones rising abruptly above the general surface of the road. It is this which causes granite macadam roads to be so unsuitable for light-springed vehicles such as cyclists use. The author has recently been led to investigate the cause of complaints arising from cyclists when travelling over what was apparently a well-kept road, and he has come to the conclusion that it is of as much importance to have stones of different sizes, as it is to have a maximum size. The proportion of different sizes requires yet to be determined. So far as his investigations have gone, he gives the following as closely approximating upon the proper proportions of sizes :—

	Maximum weight. oz.	Minimum weight. oz.
Granite and similar rocks	3½	½
Flints and similar stones	5	¾
Limestones and similar stones	6	1

one-half of the total quantity to be of the maximum weight, one-eighth of the minimum weight, the remaining three-eighths to be composed of stones varying between the maximum and minimum. This brings us to the question of binding materials; a road formed of different sized stones will require no binding materials. In a former paper on this subject published ten years ago, the author stated his conviction that the "decadence of modern roads commenced with the using of binding material," the introduction of which was coincident with the use of stones broken to a uniform size. Longer experience has confirmed this, and though in practice he is compelled to use materials to bind (?) roads he does so very sparingly, and only because of the inability to obtain materials broken to various sizes, in sufficient quantity. If the demand is, however, generally set up for proportions of different sized stones, the necessary quantities will soon find their way into the market.

Stone-breaking Machines.

The introduction of stone-breaking machines has also greatly deteriorated road-mending materials in some parts of the country. No machine has hitherto been made which successfully gets over the cubing difficulty. The tendency of all machines is to deliver a great quantity of irregular pyramidal form. The extra cost of employing hand labour—about one shilling a ton on the average—is probably compensated for in the favourable form given to the stones when broken by manual labour.

There are a few other points to which brief allusion only will be made as they are so well understood (though not practised) that it is unnecessary to prolong this paper to discuss them. They are the method of spreading materials; on suburban and rural roads the stones must be placed neither too thinly nor too thickly, but in sufficient quantities to enable the stones to form a complete surface over the old roads. As rolling cannot be attempted on roads coming within the scope of this paper, the author lays it down as a canon law for the repair of such roads that repairs should always be done in wet weather. A falling barometer in the winter will indicate to the surveyor the proper time to repair roads.

Scavenging.

It is absolutely necessary for the preservation of road surfaces with economy to scavenge roads. Those places where there are trees, high fences, and cuttings will require most attention. Scraping by machine and rotary brushes drawn by horses will be found 33 per cent. cheaper than hand scraping and equally effectual.

Unit of Cost.

It is of primary importance that a standard of comparative cost should be set up, so that road authorities may be able to ascertain whether their roads are being economically maintained. County authorities attempt a comparison by fixing the unit of cost at per mile—a few authorities reduce their calculations to the superficial yard. It is obvious that both of these methods are entirely misleading, as the chief factors of road destruction are eliminated. It is necessary to ascertain the number of the vehicles and their weight and that of their burdens, passing over the road in each year, and the width of the roadway.

We are then able to calculate what burden the road carries in proportion to its width, and a comparison can be obtained; though the results of these figures will be misleading if any attempt is made to compare paved roads with macadamised roads, or roads of very great traffic with roads of moderate traffic, as the conditions under which the materials are destroyed are quite different. An instance of this is observed in the cost of macadamised roads. In a paper read by Mr. Deacon before the Institution of Civil Engineers, the maintenance cost of a macadamised road is given at 2*s.* per every 100,000 tons per annum per yard of width, while sett pavements are quoted as low as 0·25*d.* for the same unit of cost. It is well known that when streets are repaired by macadamising the cost increases in geometrical progression, or nearly so, as the traffic increases beyond a certain number. The author gives below the actual cost of the Western Road, Hove, Brighton, which has a traffic of 164,620 tons per annum per yard of width, and the cost is 5·22 for the same unit, while the author ascertained that a portion of Piccadilly cost 3*s.* 6*d.* for the same unit.

TABLE.

MAINTENANCE COST OF MACADAM PER 100,000 TONS PER ANNUM PER YARD OF WIDTH.

	s.	*d.*
Liverpool	2	0
London	3	6
Brighton	0	5·22

This difference is so great that the explanation must be given: in the two former cases the streets were those of enormous traffic, the macadam in wet weather was churned up into mud, and after frosts would be "lickey," with the stones adhering to wheels; the road would have to be repaired many times in the year, while in the Brighton case the macadam stones were always in their place.

This is cited to show that the costs of urban and suburban roads must not be compared with rural roads, but for comparison they should be divided into different classes, thus:—

Roads with a traffic of less than 10,000 tons per annum, per yard of width;

Roads with more than 10,000 ditto, and less than 50,000 tons per annum, per yard of width;

and so on.

It is for the County Boards of the future to keep such accounts as will enable proper comparisons to be made.

In conclusion, the author believes that no change for the better is likely to be brought about in the maintenance of rural roads until the present system of road administration, and the incidence of cost, are radically reformed.

DISCUSSION.

A vote of thanks to Mr. Ellice-Clark for his excellent paper was proposed by Mr. Hodson, and carried unanimously.

Mr. J. P. SPENCER: It affords me great pleasure to find that this subject has been brought forward to-day. It has been thought that anybody can make a road, but a more erroneous impression never existed. It is only by the subject being taken up by practical men, who have studied the subject as Mr. Clark and other Members of this Association have done, and by having the matter thoroughly discussed and gone into, that this very erroneous idea can be got out of the minds of those who have the charge of rural roads. I can quite bear out what Mr. Clark has said as to the failure of the Highways Act, and also the failure of many authorities to obtain damages for extraordinary traffic. It really, in fact, amounts to this, that those rural authorities who have never tried it before, think they will obtain extraordinary damages, but when they take their case into court, they find that all hinges as to whether damage has been done or not, on the hard swearing of the different witnesses brought forward. The practical question of the cost of making roads is certainly not the least important part of the paper. Mr. Clark brings forward the point of the different sizes of stones. There is just one point I should like him to explain afterwards, and that is, where stones of different sizes are used, in what manner they should be applied; I mean just briefly, without going fully into detail; for instance, would he have each layer rolled as laid on? The subject is one well worthy of our attention, and I hope that this will simply be the precursor of other papers dealing with this question at future meetings. I should have liked to have entered more into this subject, both as to legislation and the repairs to these roads, but time is so limited, and I prefer to give some other gentleman the opportunity of saying a few words.

Mr. Vawser: I should just like to say a word with reference to the paper we have heard read. With regard to the practical part of it, Mr. Clark speaks with great knowledge, and his evidence is very valuable, being founded upon actual experience. There is nothing in what he has said relating to the construction of roads with which any of us can find any serious fault. The only thing which occurred to me—and it is a matter of small importance—was, that Mr. Clark advocates the advantage of using rotary brush machines for scavenging roads in preference to hand sweeping, as being more economical. I quite admit the cost per square yard of cleaning a road by horse rotary machines will be much less than by hand labour; but, so far as my experience goes, you do infinitely more damage to the roads by using these machines, and any gain in the way of saving labour is altogether destroyed by the additional wear of the roads by the machines. The only other question I wish to speak to is in reference to Mr. Clark's suggestions for improving the district Boards which are to do the work. Mr. Clark says, sweep away all existing authorities, and then (so far as I understand his meaning) create another authority, which shall execute the duties and cover the ground now occupied by various repairing authorities. I am inclined to think such an arrangement will give rise to great inconvenience unless established with very great care. None of us know what form the County Government Bill will take, and I am under the impression it would be far better to enlarge the powers of existing local authorities than to establish new authorities. I would make the urban and rural sanitary authorities responsible for the roads within their districts; and by offering greater facilities for amalgamation amongst existing authorities, I think, in the course of a very short time, you would have larger and consequently more influential authorities than you have at present, and their work would be more efficiently performed. I do not think it is to the advantage of the country at large, or even to a district, that Government aid should be granted in any case for the purpose of maintaining roads, and I think it would be much better for each district to be made responsible for the efficient repair of their own roads. It is an important thing, I think, that the district authority which has charge of the roads should have charge of the sewers, and also of the gas and water pipes. If you are going to leave one local authority to construct sewers, and another local authority to construct and repair roads, there will be great complication and difficulty.

Mr. Clark: I distinctly say they all ought to be under one authority.

Mr. Vawser: My point then is, that the roads ought to be repaired by the urban and rural authorities.

Mr. Fowler: Mr. Clark's remarks on sanitary engineering are always received with very great respect, because of their value; and his present paper, so far as it goes, is a very good one. There are certain points, however, which I should have much liked to have heard him discuss; but that, of course, would have necessitated a much longer paper. One point is the noise created by the use of different materials; the wear and tear from different vehicles; and the dust and dirt arising from different materials. I will take noise first. As we are a body desirous of protecting the health of the individuals we represent, I consider noise is a very serious matter; and in many of our large towns it is so great that it affects the inhabitants seriously. Then as to the gradients of roads, Mr. Clark says the cross section should be 1 in 30. Well, in my practice, I may say that in my judgment, I find that rather too steep. I have arranged and made over a hundred miles of roads, and have made a great many 1 in 30 cross section; but I find that is far too steep, for the reason Mr. Clark has given. Horses will go naturally to the centre of the road, and from the traffic going there principally, the centre of the road will soon get out of repair. If you make a street as near level as possible, you will find that the whole traffic is pretty evenly distributed from kerb to kerb; and when you get the traffic distributed in that way the wear is pretty uniformly all over the street. I am one of those who take advantage of the opinions and experience of those who have to use the roads—the omnibus and cab drivers of London, for instance. I very often get on the "dickey" in London, to have a chat with the omnibus driver, and if you ask him what sort of a road he likes for his horses, he will tell you to make it flat from kerb to kerb. The Poultry, which has the largest traffic in the world, and the Strand, are nearly level from kerb to kerb. I think, if we look well to the foundation of a road, and satisfy ourselves that the weight of traffic will not settle the centre, we may then always make a road flat from kerb to kerb, or nearly so.

Mr. W. Spinks: I have charge of about two miles of main roads, and I must say I agree with Mr. Ellice-Clark as to the difficulty of carrying out the provisions of the Highways and Locomotive Act of 1878. About two years ago I had to remodel a length of road, one half of which was ordinary macadam of broken stone, and the other half gritstone paving, and the footpaths partly flagged and gravelled. Seeing the difficulty there would be in getting a contribution from the county towards this work, I got the county surveyor to come and look at it, and we agreed upon terms. He agreed to pay one half width as macadam, and half the other width as paving with granite sets and asphalted joints, and 1*s*. per yard to foundation, and also half the cost of recurbing and reflagging the footpath. This year I am renewing about 1000 yards in length of main road, partly boulder and partly gritstone paving. I asked the county surveyor if he would treat us the same as before? He replied "Certainly not," and said the county only undertook to contribute to the repair of roads as they found them; that they looked upon boulders as out of date, but would pay a price for gritstone paving, but that footpaths they repudiated entirely. The foundation is consequently being formed of the old materials.

and we shall pave the road with gritstone sets, and distribute the works over three or four years, to which the surveyor agrees. It is also intended to renew the footpaths, but a circular has been issued by the Cheshire County Highways Committee, of which Lord Egerton of Tatton is the chairman, repudiating all liability for footpaths, on the ground that the Act was only intended to apply to disturnpiked roads. We are going to keep an account of the cost, however, and shall ask the county to contribute towards it. It seems to me that the Accrington case—which held that the highway means from one side of the street to the other—laid it down that footpaths are included; and I want to know if Lord Egerton of Tatton is to determine absolutely what is the meaning of the Act. I should like to hear from Members of this Association what is the practice in other counties in such cases.

Mr. DE COURCY MEADE: I should like to ask Mr. Ellice-Clark how he arrives at the approximate amount of traffic passing over a road?

Mr. ELLICE-CLARK: By counting it.

Mr. DE COURCY MEADE: Then as to the remarks of Mr. Fowler; I know there is a rise in the Poultry of 10 or 12 inches, though it may look flat. I levelled the place some years ago, so I can speak with certainty on that matter.

Mr. J. PRICE: I think we shall all agree with the opinion expressed by Mr. Ellice-Clark as to the different authorities which have the management of rural roads. I formerly represented a rural sanitary district where we had sixty miles of highways, and where there were no less than ten different highway authorities, from the ordinary parish surveyor to the small Highway Board. The salaries paid to the different surveyors amounted to about 200*l.* a year; and I think every one will agree that for 200*l.* a year a competent man could be obtainable to supervise the whole 60 miles. An application was made to the county justices to take over the highways under the Act of 1878, and they replied, in the course of six months, that they would give the matter their consideration. I believe it is under consideration still, and is likely to remain so.

Mr. W. H. WHITE: I do not wish to criticise the paper at all; but a question was asked by Mr. Spinks as to the practice of other counties. I can speak for the counties of Oxfordshire and Berks, and in these counties nothing whatever is allowed for the repair of footpaths.

The President: Mr. Ellice-Clark has alluded to a paper which I read before this Association in 1879. This was principally respecting the Highway Act, which had been passed the previous year. I think it came before the Association somewhat prematurely. Very few Members had had any experience of the Act, or knew what it was about; but in Hanley we had good reasons for being well posted up in this Act whilst it was before the House of Commons. The town council, in August 1878, the very month this Act received the Royal Assent, had decided to pave one street, but we found that we could get nothing back from the county, and the county authorities would not contribute anything towards the capital expended, or interest on it. The project was therefore abandoned, and the council continued to keep it in repair as it then was. I refer to Old Hall Street, a continuation of the street in front of the Town-hall. But when Hanley got a separate Court of Quarter Sessions, this subject was renewed, and it has been repaved with Clee Hill sets, 3 × 5, on a suitable foundation. The Act seems to me to put a stop to the proper improvement of roads in towns. Repayment on account of footpaths we never attempted to press on the county authorities. There was no chance whatever of getting any contribution towards footpaths, because the town council had always kerbed and channelled and kept footpaths in repair by the side of turnpike roads. We were met at the outset by the question, "Did the turnpike trustees repair the footpath?" We were obliged to reply that they did not, and of course we could get nothing from the county; but, where the turnpike trustees repaired the footpath, I should think the county authorities would be liable to contribute. The Act has been a failure, there is no question about that; but, when I read the paper at Leeds, the idea in my head was that the Act was passed to benefit small country districts, and that they were going to be a great burden on the ratepayers of towns like the Pottery towns. I believe myself that the feeling of those who promoted the Bill in Parliament was, that this would be the case, and that it would be an assistance to those country districts to maintain their roads in a satisfactory state. But, in Staffordshire, I think the very opposite has been the case; and parties now repent the course they took in helping the Act forward. There are some towns which get more than they contribute in the shape of rates; but Hanley, having a separate Court of Quarter Sessions, is entirely out of it now. As to using different sizes of stones for roads, I have not tried it myself, but I think it is worth trying, particularly on rural roads. There is no doubt that a small amount of binding material is necessary, particularly with such gradients as we have in Hanley. Mr. Vawser does not approve of rotary sweeping machines, but I do not myself find that they do any harm to the roads; nor do scrapers; but there are certain times when we cannot use either. I should like to have had the main road between Stoke and Hanley cleaned, but we found we could do nothing with the brush machines, and it was not moist enough to do anything with scrapers.

Mr. ELLICE-CLARK: The paper read has answered the purpose desired; it has raised a discussion and has elicited the opinions of different surveyors throughout the country. The opinions enunciated to-day, more than ever, convince me that the present authorities for the repair of roads should be abolished, and that they should be consolidated. That really is the gist of the first part of the paper. It appears, from what has transpired to-day, that surveyors in proximate counties differ in what is allowed for main roads, and that in Cheshire the surveyor will allow for certain things one year, but will not allow anything for the same things the next year. It shows that the system of the maintenance of roads by different road authorities ought to be abolished. The paper really is a plea for the establishment of county boards, to undertake not only the duty of the maintenance of main roads, but most of those duties that are now thrown upon local boards and municipal corporations. The only new idea in the latter part of the paper, in reference to maintenance, is the use of different sizes of stones, and in not using binding materials. I hope that surveyors present, who have macadamised roads to maintain, will have some section laid down as described, and that we shall, at some future meeting, get the benefit of their experience.

THE ECONOMIC PRODUCTION OF COAL GAS.

By R. P. SPICE, C.E.

Among the various classes of professional economists of the present day, the coal gas manufacturer deserves a niche in the muster roll of fame.

It has been truly said, that the man who succeeds in making three blades of grass grow where only two had grown before, is a benefactor to his country; and in measuring the importance of coal gas manufacture as a national industry by the enormous supply which is constantly required to meet the demand for gas, by the many millions of people who depend very greatly upon that supply for satisfying their daily wants, in regard to light and heat, for manufacturing, commercial and domestic purposes, I have been led to the conclusion that as an art and industry, it is fully entitled to occupy a high place in the scale of those economical agencies by means of which the solid financial prosperity of the United Kingdom is materially augmented.

In its early stage of existence, the art of producing carburetted hydrogen gas, on a commercial scale, had to encounter and struggle with difficulties to obtain a footing, and to secure the favourable regard of those who wanted a better means of obtaining artificial light than was afforded by the "tallow dips," or the train-oil lamps of their forefathers. Great indeed were the opposing forces of the many unbelieving and self-interested objectors to the adoption of the new light of King Coal, introduced by the ingenious Cornish miner, William Murdoch.

These adverse influences were, however, in the course of two generations of the human family, all overcome; and in the succeeding generation, which is now passing away, the progress of gas lighting has been marked by uninterrupted growth, increasing prosperity, and rapid expansion. This progress has been greatly stimulated by the healthy rivalry of our electrical brethren, by whose skill and devotion the science of electric lighting has been raised to its present highly advanced state of perfection; and aided also by the ingenious devices of thoughtful men in our own ranks, so applied in practical working as to result in improving quality, increasing purity and efficiency, and decreasing the cost of production.

I do not propose on this occasion to go into the history of the host of economical methods employed at the present time for producing crude coal gas in the state in which it leaves the retort; but in complying with your request for a paper on "Modern Gas Manufacture," I purpose to treat the subject in a popular, rather than in a technical way; and I therefore purpose to commence the review at a recent period, with the consideration of the preparation of coal for carbonisation.

In the ordinary way, for half-a-century at least, it had not been part of the routine of the business to prepare the raw material in any way; just as it came from the ship or the railway, so it went into the coal store, and from thence it was conveyed into the retorts.

But, within a recent period, it has been found profitable to prepare the coal by passing it through a coal-breaking machine, by which the large lumps are broken into small pieces, so as to admit of the whole being raised by an elevator composed of buckets, made of sheet-steel, carried on an endless chain, and delivering into a fixed over-head hopper, from which it is allowed to fall, when required, into a lower hopper or receiver; this receptacle forms the upper part of a retort-charging apparatus; the whole of it, with its supply of coal, is carried on wheels, and propelled on rails laid in front of the retort benches. The charge for each retort is dropped from the hopper into a little wagon, which, running on suitable wheels, is pushed forward into the retort, and by a simple mechanical arrangement, the coal is suddenly deposited in a uniformly thin layer on the bottom of the retort; the wagon in an instant is withdrawn, the charging machine pushed forward to the next retort on the same level, and the lid of the charged retort closed; the whole process of drawing and charging being completed in one minute.

The advantages thus secured are considerable.

Firstly, there is a saving of time in performing the operation of charging and drawing, thus permitting of a greater number of retorts being worked by the same number of hands.

Secondly, there is less gas lost in proportion to the shorter time during which the retort is open while the charge is being deposited.

Thirdly, the charge being laid in a uniformly thin layer, the heat of the retort acts more rapidly and effectively upon the coal than is possible when it is laid in a thick and unequal mass, composed of lumps of various sizes and small particles; and as this saving of time amounts to one-third of that required on the old plan, it follows, that only two-thirds of the number of retorts need be employed to do the same amount of work as formerly, and the saving in capital is in the same ratio.

Fourthly, there is the advantage of being able to effect the extraction of the gas from every part of the charge of coal at the same instant of time, without having to wait for the heat to penetrate to the interior of the mass till the outside of it is over-done, and poor gas thereby be evolved before the centre of the charge is carbonised.

And, fifthly, by these mechanical aids, the character of the labour employed in the retort-house is rendered far less trying to flesh and blood than it can possibly be without them.

The apparatus thus briefly described is known as "West's Patent Charging and Drawing Apparatus"; and after having seen and considered the merits and demerits of all other contrivances, designed with the same object in view, I have arrived at the conclusion that for simplicity, economy, and general efficiency, it is entitled to rank first in the list.

So much, then, for the ground-work, or first stage of the manufacture. We now come to the consideration of the means employed for removing the impurities contained in the crude gas as it commonly leaves the retort. Formerly, all these impurities went forward, and purification was effected for many years by the use of wet lime, that is to say, lime and water, in iron boxes; the mixture being mechanically agitated while the gas was passing through it, and when the lime had become saturated and spent, it was run off into pits or chambers to dry; the residuum was called "blue billy," and, on exposure to the atmosphere, this became a choice nuisance, as a specimen of very pungent perfumery.

This system was superseded by the adoption of the dry lime method, which was a nuisance of less degree, and long held in favour because of its effectiveness for the purpose of purification; so effective is it, that antiquarian gas-men of the fossilised type still employ it, notwithstanding its being a nuisance to all who are obliged to live within a mile of a gaswork, where fresh and balmy breezes, which would, in their purity, be healthful, convey the noxious stench into the atmosphere surrounding inhabited districts.

Some years since, oxide of iron became used as a purifying agent, and was generally adopted in place of lime. This, however, did not satisfy the requirements of modern scientists, who soon proved that, although it would remove all the sulphuretted hydrogen, the removal of which had formerly been considered as the acme of the gasmakers' art, it did not remove sulphur in certain other forms, denominated " sulphur compounds."

And this objection was so warmly taken up by the sanitarians and analytical chemists of the period, that something like the "Wars of the Roses" resulted; battle after battle being fought with pen and tongue, till means were devised for effecting the extraction of a portion, at least, of these newly-discovered impurities.

This object was ultimately accomplished by combining the use of lime with oxide of iron: the gas being made to pass through lime purifiers first, and next through purifiers containing oxide of iron. This method is still adhered to in London and in some other large cities, notwithstanding that a far better and more reliable method has been firmly established.

The objection to the lime and oxide process is twofold; inasmuch as it is unreliable, and involves the creation of a nuisance in the vicinity of the works, and often for a considerable distance therefrom, by the stench occasioned when the lime purifiers are opened, and their noxious contents discharged into barges or other vehicles for the purpose of being conveyed away to parts unknown; as in the case of the British Gas Company at Norwich, where legal proceedings were recently taken to suppress the nuisance. Why gas companies should be so ill advised, as to continue to court such unenviable notoriety, is entirely beyond my comprehension.

The lime, when used, is first slaked, and in its primary condition, when placed in the purifiers, does very little work in the way of taking up the sulphur compounds, only attaining efficiency after sulphuret of calcium has been formed by passing sulphuretted hydrogen and carbonic acid through it; and as the chemical changes, resulting from the varying proportions of sulphuretted hydrogen and carbonic acid are constantly occurring as the gas is passing through the system of purifiers, the manager does not at all times know where he is, or what he has got; hence it happens that, with his utmost care, he cannot at all times keep

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these troublesome compounds within the limits now commonly defined by modern legislation. Consequently we hear occasionally of pains and penalties being inflicted on gas companies; the Newcastle-on-Tyne, and the Crystal Palace District Companies having recently both been fined for such infractions of the law.

And so recently as in the week ending on the 22nd of June last, the Commercial Gas Company of London failed to keep within the limits allowed in the Metropolis, their gas being then reported by the Official Examiner as containing 17·7 grains of sulphur in 100 feet, the limit allowed being 17 grains.

There is, however, no longer any excuse for such shortcomings, for it has been established beyond controversy that nothing is easier, or more certain of accomplishment, than to keep these sulphur compounds down within the limits defined by the London Gas Referees; leaving a safe margin for any occasional causes of interruption or inattention.

The method to which I refer is the now thoroughly-established coal-liming process, patented by Cooper.

It is sometimes a trial of patience to have to listen to an oft-told tale; but, at the risk of being considered tedious, I must bring before you the fact, that this method of dealing with the impurities contained in crude coal gas has been in uninterrupted use at the Tunbridge Wells Gas Works for two years and eight months; and whether in winter or in summer, with good coal or bad coal, it has never once failed to yield to the prescribed treatment, when that treatment had to be slightly modified to suit the several qualities of sea-borne coal operated upon; and so entirely are the conditions understood, that, the character of the coal being ascertained, the results as to the reduction of the sulphur compounds can be accurately foretold.

Constant practice and repeated experiments made for me by Mr. Dougall at those works, have established the rule, and placed beyond doubt the fact, that by increasing the prescribed quantity of 2½ per cent. of lime slaked by its own weight of water to 3 per cent. slaked with the same proportion of water, the sulphur compounds will be less by 2 grains in 100 feet, and every additional half per cent. will reduce the quantity of sulphur 2 grains; so that if it be assumed, by way of example, that 2½ per cent. of lime will reduce the quantity commonly contained in crude gas, from, say 30 grains to 14 grains, 3 per cent. would bring it down to 12, 3½ per cent. to 10, 4 per cent. to 8, and 4½ per cent. to 6 grains;

there is nothing uncertain, but there is entire independence of the capricious formation of sulphuret of calcium, and of the casually altered conditions; nor are any chemical experts required to be in close attendance upon the working, day and night.

The impurities which, previous to this process becoming known, were a serious cause of anxiety in the purifying house, are no longer a trouble; they are dealt with in the retort house, and about four-fifths of them are arrested in the retort, transformed by lime and heat, and rendered innocuous in the coke, which burns more freely because of the presence of the supplemental small percentage of lime; and experience has established the fact, that owing to its improved character, the demand for this coke has so sensibly increased, that there is never any in stock at Tunbridge Wells, whereas, previously to the adoption of the coal-liming process, it was commonly the case that there were from 500 to 700 tons of coke in the yard; and although 12,000 tons of coal are carbonised at these works yearly, the coke produced is sold so readily, that an order for two railway truck loads has had to wait two months for execution.

One great merit of this "Patent Coal-Liming Process" is the sanitary advantage afforded by the entire abolition of purification by lime; and the concomitant evil of mephitic odours being disseminated in the vicinity of the works, and for some distance beyond, sometimes daily, and in most cases every few days, when a foul purifier has to be opened and cleansed. The nuisance thus caused is no longer excusable, because the offence is avoidable; and to continue it is absolutely wasteful to the extent of not less than a penny per thousand feet of gas sold, even at the present low values of residual products, and after the payment of royalty for the use of the patent process.

Now if this penny, which may be saved, is not wanted to make up the required dividend in any given case, it ought in common honesty to be saved nevertheless, by being left in the pockets of the consumers, instead of being needlessly taken therefrom.

It cannot however, be pleaded, by either gas companies or corporate bodies who carry on the manufacture of gas for the benefit of ratepayers, that cheapening the process of gas making to the extent of a penny per 1000 feet is not an economy worth thinking about, when from all parts of the country the universal complaint is, that, owing to the reduced value of ammonia and tar, the profits of many gas undertakings are seriously reduced or have vanished entirely, and left in some instances, not merely an "aching void," but a serious balance to the debit account.

Under these circumstances, which have been proclaimed apologetically from "Dan to Beersheba," one would think, that as every 120 million feet of gas manufactured on the old lines cost just 500*l.* more than it could be made for on the Coal-Liming Process, men would polish their spectacles and look the facts in the face; and if they did, they would find the question proved up to the hilt in favour of the process, by actual and uninterrupted experience, extending now to close upon three years. The first of a series of five purifiers into which gas from limed-coal was first turned two years and eight months since is still at work as No. 1. It has been opened and emptied only twice in that time, and on each occasion only one-half its contents was returned to it.

The last two of the series were soon shut off because it was found that the gas was always pure before it reached them, and because, also, of its being found that on shutting off the fifth box the illuminating power of the gas rose half a candle, and by shutting off box No. 4 another half candle was gained; the consequential effect being the saving of 1 er cent. of cannel.

This fact should teach a lesson to those men who have been boasting of their ability to make oxide purifiers last for so long a time without a change, as to distance all other competitors for fame; their great achievements being accomplished by employing inordinately large quantities of oxide, and leaving the sulphur compounds in the gas. They are simple and liberal men who sell the gas they make, and give those compounds in! The ability really belongs to the oxide, and not to the men.

At the time when limed-coal gas was turned into these five boxes they contained 150 tons of oxide, 30 tons being then the usual charge for each box, but with coal-limed gas one-fourth that quantity, or 7½ tons, is ample for a box 20 feet square, for a make of 120 million feet of gas per annum from Newcastle coal, and three boxes that size would suffice for any work of that capacity.

As to the quantity of oxide employed, experience of both systems at the same works has established the fact, that on the old lines it would have cost 60*l.* per annum to keep up the stock of effective material, to say nothing of the cost of emptying, revivifying, and recharging the boxes; but with the coal-liming process it has cost nothing for material, and of the original 150 tons at first used, not more than 30 tons are now actually used, 120 tons not being required; besides which, of the stock of new oxide in store ready for use in 1882, 62 tons have this year been sold to neighbouring gas companies as surplus stock, at cost price, for the use of which, within any reasonable period, a probability could not be anticipated by the resident engineer.

But beyond the oxide costing nothing, it may fairly be reckoned that a profit will result from its use, for of the 7½ tons now in box No. 1, 90 per cent. is sulphur; and the extent to which this accretion of sulphur may be carried has not yet been ascertained; at present I can only form a rough estimate of it by taking into account the percentage of sulphuretted hydrogen arrested as the crude gas passes through No. 1 box.

The crude gas entering this box contains 300 grains of sulphuretted hydrogen, and only 90 grains are now being arrested; this shows a falling off of 208 grains in two years and eight months, for at the commencement 298 grains were arrested out of the 300, but to continue using No. 1 box, only leaves the others more to do; therefore I am continuing it merely for the sake of obtaining data for use in connection with the future development of the system.

This economy in regard to cost, or no cost of oxide, is by no means the most important advantage which has been proved to accrue from carbonising coal in the presence of lime, under proper regulations and conditions, for a great gain is realised by the resulting increase of ammonia, which amounts to 30 per cent. beyond the normal quantity. And it will hardly be denied by any man capable of managing his own affairs, that if, owing to the reduced market value of any article of commerce, say sulphate of ammonia for instance, he can only realise half the profit he formerly made, the cost of production remaining the same in both cases, he will improve his balance sheet by increasing his production, provided he can accomplish the increase without employing any more capital or adding sixpence to his expenses.

By way of illustration, take the case of a yearly sale of 1000 tons of sulphate of ammonia, and put the present profit as low as 5*l.* per ton:—

	£
The net profit would be	5000
The 30 per cent. increase would give an additional ..	1500
Bringing the net profit up to	£6500

The next step in advance to which I would refer, as affecting the economical production of coal gas, is the application of the principle of gaseous firing to the carbonisation of coal. This, however, although it has only recently come to the front, was initiated many years ago, and was the product of the fertile brain of the late Sir William Siemens, whose name to us will always be "familiar as a household word."

Others have followed up his ideas, and various have been the results achieved. I need not detain you by referring to the various systems or designs for generative or regenerative furnaces. Some are costly contrivances and objectionable on that account, and also because of their being complicated, neither of which objections will apply to the last which has come under my notice; and that is the one designed by Mr. William A. Valon, of Ramsgate, which, for the economical heating of retorts, I regard as being the essence of simplicity; and as one-half the coke formerly used for heating ovens, containing seven retorts, does the same work effectively, with less cost for wear and tear, and the abolition of the most trying part of a stoker's duty, namely, the furnace work, I am satisfied with it and have adopted it. But it does not please everybody; it would be a miraculous furnace if it did; I am however, not at all sure that trying to please everybody is a "game worth the candle;" Æsop's familiar fable of the old man and his donkey is a case in point.

However, let that be as it may; let the grumblers grumble, and the contentious contend for their various fads and fancies, it is something to be thankful for that one-half the coke hitherto used as fuel, may in future be saved; and of the other half, two-thirds may be saved by tar being used in its stead; for, with the generative furnace nothing can be better than tar as fuel, for maintaining uniform heat in retort ovens, which is a fundamental consideration, always assuming that proper means of delivering the supply in a regulated stream be employed; and here again I may mention, that of the contrivances I have seen for using tar as fuel in the gas works of the United Kingdom, I regard the Ramsgate tar-tap, perfected by Mr. Bennett, to be the best. Concerning its practical working, I have found that in Valon's furnace, one pound of tar will do the same amount of effective work as between four and five pounds of coke; but taking it at only four pounds of coke replaced by one pound of tar, the following will be the result of a year's working at one works with which I am intimately acquainted:—

As 1 lb. of tar will do the work of 4 lbs. of coke, and the value of tar at these works is one penny per gallon, coke being worth 15*s.* per ton, I take one gallon of tar as equivalent to 12 lbs. of coke, which represent the penny; the 4 lbs. of coke multiplied by 12 gives the quantity of coke saved by the 12 lbs. of tar, namely, 48 lbs.

	s.	*d.*
The value of 48 lbs. of coke at 15*s.* per ton	0	4
The value of the tar used in lieu of coke	0	1
The result is a gain of	0	3

Now, if no more than 100,000 gallons of tar be used as fuel at these works yearly—and much more may be used—the saving effected per annum by the substitution of tar for fuel in lieu of coke will be 100,000 times threepence, or 416*l.*

In concluding this paper I desire to place on record a fact, obtained from a new source, concerning the effective action, so constantly and uniformly experienced in using the Coal-Liming Process.

The new source to which I refer is an important and high class sea-side health resort, where the gas supplied has hitherto been purified by lime only; and at these works nothing has been spared to minimise the nuisance occasioned by the exposure and removal of the foul lime which has long been a trouble.

Within the last month or so, the process has been introduced there, and is working with the same degree of satisfaction as at Tunbridge Wells; the latter being the smaller work of the two.

The sulphuretted hydrogen contained in the crude gas at the inlet of the purifier, at this latest scene of its triumph, was reported to me, under the date 18th June, as being 260 grains in 100 feet, and of this 255 grains were arrested in the first purifier, leaving only 5 grains to be taken up by the second box. Prior to the change from the old system to the new at these works, the crude gas made from the same stock of coal, contained 900 grains of sulphuretted hydrogen. Thus it is clearly shown that before reaching the purifiers, the crude gas in this case had its impurities reduced from 900 grains to 260 in 100 feet, and of the 260 grains, only 5 grains were found at the outlet of the first purifier.

And here I leave the narration of the facts, which, at your request, I have compiled; but, if it be thought that no more can be said in favour of the modern improvements to which I have approvingly referred in this paper, it would be a delusion, which the Association of Municipal and Sanitary Engineers and Surveyors would never be considered capable of entertaining. In this direction much more may be said, and very much more will be done; let who will preach the doctrine of finality.

DISCUSSION.

Mr. GORDON: I am sure we have all listened with very great attention and pleasure to the paper Mr. Spice has just read. I feel we all owe a deep debt of gratitude to that gentleman for giving us such an interesting and valuable paper. I listened with a great deal of pleasure to a description of this method of purifying gas, at our meeting last year in London, and I am glad that Mr. Spice has given us still further information respecting it in his paper this morning. We do not profess—at least many of us do not—to know much about gas-making; but, as representing a Corporation who own gasworks, I feel very deep interest in the subject. I feel many other gentlemen present will have been equally interested, and I am sure I am only expressing the feelings of you all, when I say that we are deeply indebted to Mr. Spice. I have therefore great pleasure in proposing a vote of thanks to Mr. Spice for his very interesting and valuable paper.

Mr. VAWSER: Only as a matter of form is it necessary to second the vote of thanks proposed by Mr. Gordon. We all feel the thanks we thus formally express. I was not aware until to-day that polluted lime was capable of being described in such glowing and poetical language as Mr. Spice has used; but it seems that even a nasty subject is capable of being clothed in words which make it much more pleasant to the senses. The paper teems with valuable suggestions and ideas as to the relative advantage of oxide and of lime purifiers, the increased value of the coke, the additional value of the gas, and the more complete if not the total abstraction of the sulphur compounds by the process Mr. Spice has described. It is a marvel to me that the process has not been more largely adopted. I asked Mr. Spice last year how it was that the process was not more generally used, and the explanation which he gave at that time was, that it had not been sufficiently tried. It appears now, that although it has been used at Tunbridge Wells for twelve months, only in one other place has it been adopted. Some explanation of this might be given—should be given, I say, by those Corporations who have bought gasworks, at their outside value, and are devising all sorts of schemes for economy in the production of gas. Some explanation should be given, I say, why these Corporations do not employ this cheaper and better process. It appears to me that the statements made by Mr. Spice, with regard to the additional purity of the gas, from the abstraction of the sulphur compound, are such as cannot be contradicted; and I have read other papers which bear out the same truth. Mr. Spice also describes and expresses approval of West's patent system of charging retorts. I had an opportunity, a few months ago, of seeing this apparatus in work, and it did its work very well indeed. So far as my limited experience goes, it is the best method of charging retorts, and results in a considerable diminution of manual labour and is a source of considerable economy. I do not know what the cost of the machines would be—probably it would be a considerable sum; but there is no doubt there are corresponding advantages from the adoption of the system. Mr. Spice speaks of the fine inflicted on one of the London gas companies for supplying gas containing too large a proportion of sulphur, but he did not mention the amount of the fine, or at least I did not catch it. Possibly it may suit the companies better to pay small fines than to incur the additional expense that might be found necessary to purify their gas of these compounds, and it may be these fines ought to be increased by the magistrates, so as to compel some improvement to be made. I have very great pleasure in seconding the vote of thanks to Mr. Spice, proposed by Mr. Gordon.

The vote of thanks was unanimously accorded.

The President: The paper is now open for discussion, if any one wishes to say anything.

Mr. Spencer: I should just like to say how very much I appreciate the excellent paper which has been brought before us to-day by Mr. Spice, and how heartily I support the motion which has just been carried. Mr. Spice has treated this subject in a way which all of us can appreciate—I think not only those who have technical knowledge, but every one of us—in respect to two points—(1) as to the nuisance which is created very frequently by the ordinary means of purification, and (2) as to the reduction in the cost of production. Now, apart from all technical matters, these are two very vital and important points, which must come home to every one of us, whether we have gasworks in the hands of our Corporations or not. I should like to ask one question, suggested perhaps by the want of technical knowledge on my part. Mr. Spice in his paper spoke of the very excellent results obtained by West's patent system of charging the retorts, and stated that it is the practice now to break the coal, which is then taken up by endless chain carriers. I should like Mr. Spice to say whether, in his opinion, it would be possible, with due regard to the proper manufacturing of gas, to use the small coal already produced in such abundance at collieries? Of course I am not speaking so much now of cannel coal as of ordinary gas coal produced in the counties of Durham and Northumberland, where, in getting the coal, a large amount of small coal is produced, and which has, I believe, at present to be used for inferior purposes. My asking this question may be put down to my ignorance, but it appears to me an important one, if it should be a practical one. The question of the purification of the gas is also an important matter, and it appears to me that the coal liming is the better method, and that it also practically removes a great nuisance. I hope the information Mr. Spice has so lucidly put before us will be widely disseminated in the various districts to which we shall shortly return, and thus cause the subject to be investigated; and, if approved of, that the method he describes will be adopted in many instances. Of course there are difficulties in the way, as there always are where plant has to be altered, but we must trust that the practical benefits will be so clearly demonstrated that this obstacle will be removed.

Mr. TARBOTTON (Nottingham): I am not entitled to speak except by your kind invitation, as a visitor; but I should like to say just one word with regard to the paper Mr. Spice has favoured you with to-day. Respecting it generally, I may say that it requires a considerable amount of careful thought. The proposal is new, and like all new things it has to go through a number of phases. I believe the want of general appreciation of the application of this process is due to absolute and distinct prejudice. That has been the case, I know, in many parts of the country. People either will not try it, or oppose it without that knowledge which they ought first to obtain. You can judge from the paper what the process means. It means dealing with the sulphur compounds, which we have to deal with in gas-making, initially, in the retorts themselves, and if the facts be as stated—and I have no reason yet to doubt them—it saves an enormous amount of cost in purification and labour. I only hope that the large makers of gas, in the great towns of England, will give more attention to the process than they have done, and I think they will do so, from what has happened during the last twelve months. There is always, in connection with new things, a kind of fault-finding tone, when people either find fault or do not investigate things for themselves. That reminds me of a little story I may tell you. There were at one time heathens in the world, and there were heathen gods. There was a certain heathen god called " Momus," the god of fault-finding and state raillery, and he found fault with the house Athéne built, because it had not wheels to carry it away from its evil associations.

Mr. Graham: Perhaps Mr. Spice will help me out of a difficulty with respect to one of the products of gas-making, and that is " blue billy." There is a large gas company in my neighbourhood, and brickmakers who have taken clay out of the ground to make bricks are glad to get materials to fill up the holes thus made. The " blue billy " is put in and buried, but there is such a slope that the water flows down from where the " blue billy " is, and is very objectionable. Is there no simple process by which the " blue billy " can be deodorised before disposing of it in this manner, or is there no other means of disposing of it. This is a difficulty with my Corporation, because, having constructed a sewer in the direction of this outlying district, they were asked to take the sewage of it. Taking their sewage necessarily requires us to take a certain amount of effluent water, which is contaminated with blue billy. The result is that, from every manhole and ventilator, such a stench arises that it is a great nuisance. If he could suggest any other means of disposing of " blue billy " than burying it in the land, I should be very much obliged to Mr. Spice.

Mr. Spice: I assure you I feel very highly flattered by the kind reception my paper has received at your hands. I had great pleasure in complying with the request of my friend Mr. Cole, who was one of my audience at a meeting in London, where some men " who went to curse, remained to pray." I refer to this now as an illustration, by way of reply to Mr. Vawser, who wonders—and will continue to wonder until " a change comes o'er the spirit of his dream " of the gasmen of to-day—how it is that so few gas companies have turned their faces towards this process, or favour it. Well, scarcely anybody had favoured it two years ago; but truth will prevail, and nothing can permanently stop its spread and growth. And it will be so in this case. I have been working alone in this matter, but no man has dared to contradict a single fact that I have stated in connection with the process, which I have now been publicly advocating for two years and a half. That, in fact, has been my misfortune, for if any one had only laid hold of some fact, and even said we will suppose that is not true, I should have laid hold of that man and have pounded him until his mother would not have known him—metaphorically I mean, of course, as I am such a mild individual I would not hurt anybody. I am glad, however, that they have not attempted to shut me up in prison as a heretic, as they would have done in olden times. The first outcry of failure was, that the scheme was a revolutionary one, and men would not have it. One man had tried it at his works and found the coke covered with yellow spots; I thought he was going to say that the coke had got the yellow fever. Now I have not seen, and nobody else has seen, a bit of yellow spot on coke made by the presence of lime in the retort. There are some spots of lime, such as you would expect, but you would not notice any difference at all. Generally we use 30 per cent. for fuel, and the other 70 per cent. is sold, containing 2½ per cent. of lime, and the coke is so improved by the process that it requires less oxygen to maintain combustion. If this fact is disregarded, and you go on using as much lime air as you did with the other, then the intensity of the combustion would ruin the furnace; and this has been done in one or two instances, where the men did not know how to handle it, and had not the patience to find out. We had that patience at Tunbridge Wells, and, as there is never an effect without a cause, never anything happened there but we found out the cause, and then there was never any further difficulty. With regard to the question as to the disposal of "blue billy" on hillsides, I would not look at it; I would turn my back on it. "Blue billy" has no business to exist at all on your roadside slopes, where the rainfall must carry some portion of it into your sewers. When it has been found out that "blue billy" is not necessary, I say it is an abominable crime that a nuisance like that should be continued and perpetuated. My answer is, do not create "blue billy"; nobody wants it; it is good for nothing, and in many places it is a source of great mischief. Its exposure annoys everybody who has anything to do with it in any shape whatever. Leave off using lime in the purifiers, and use a preparation of it in the retorts only, where conversion of the sulphur compounds takes place every minute of the year. Mischief is thus removed, profits are increased, and cleanliness and perfection of quality are attained; and with regard to coke and the increase of that fertilising agent sulphate of ammonia, which has more stimulating properties than ordinary guano, I say we are really conferring a benefit on the country by increasing a valuable commodity instead of failing to produce it, and allowing it to go where it is not wanted. I would say, in answer to Mr. Vawser, that there is no reason why the system should not be tried everywhere. There is less nuisance, and to try it need not involve the expenditure of a single shilling. I am prepared to try it anywhere, and to prove anywhere that all I have said respecting the system is perfectly true, and that it is a saving of waste and a blessing. I never mention the towns where I am engaged, but I have received permission to state that the fashionable seaside town to which I have alluded in my paper is Folkestone. The secretary there writes to me: There was not a single grain of sulphur except in the first purifier. There are three purifiers, and for the first time in our history we have three clean purifiers at the end of a month's work, after having made more than 11 million feet of gas." I have also to announce to you that Boston in Lincolnshire has decided to adopt the system.

ROAD-WATERING.

By W. SANTO CRIMP, Assoc. M. Inst. C.E., F.G.S., M.S.I., &c.

The subject proposed to be discussed in this paper is of such a simple nature that it would almost appear to be unnecessary to occupy the time of the Members of the Association in reviewing its details. But on examining the returns of the various town surveyors who have been good enough to reply to the enquiries of the author, much material for thought will be found as well as many interesting and valuable statistics. In addition, the absence of reliable data relating to the subject—except to a very limited extent—indicates the want of such a paper, which want it is hoped may be met to some extent by the information collated in these pages, and to a much greater degree by the discussion which the author anticipates will follow its reading.

It is unknown at what period roads were first systematically watered for the purpose of laying the dust. Possibly the earliest method, and one even now practised, was that of dipping water from the nearest source, and then by a deftly executed swing spreading the contents of the bucket evenly over the ground.

In a letter recently printed in the "*Times*," it was stated, that in Mexican cities, even at the present time, each householder waters the area in front of his house by means of water bottles, every day before sunrise, a stage of co-operation which will never be reached in the land of the grumbling Briton.

In India, water carriers, provided with a large pig-skin vessel, having one of its legs ingeniously adapted as a distributor, may be seen sprinkling the contents of the vessel on the surfaces of the streets, a truly primitive method.

In his useful handbook, Mr. Boulnois mentions the plan of damming the water running along the channels, and ladling the contents on to the surfaces of the streets by means of wooden shovels, at a period of course, when water was distributed more liberally than now, and when iron mains were unknown.

We can no longer revel in the luxury of clear and limpid streamlets running with delightful freshness alongside the dusty ways of our Modern Babylons. The octopus-like water company establishes itself, and armed with statutory powers excels even its prototype in its power of suction. The 52nd section of the Public Health Act even provides for the company a rock, under the kindly shelter of which it fattens prodigiously.

The necessity for watering our streets is of course premised. In populous towns with great vehicular and pedestrian traffics, and the consequent manufacture of vast quantities of fulsome filth and dust (doggies, too, are factors), it is of the greatest consequence for the health of the community, that the food exposed in shops for its consumption, should not be rendered unwholesome. That clouds of dust and filth must prove deleterious to both our food and the air, must be conceded by all sanitarians.

Even the protection of our clothing is an element requiring consideration. See for instance, that spic and span denizen of the suburb, who admits being "something in the city." Attired in glossiest of hats and boots, and with a faultless get-up generally, he carefully wends his way to the station; and woe to the surveyor if the road is too dusty or too wet and muddy. In such cases, when the "something" has assumed a tangible form, and our friend is found piloting a quill in a dingy city office, he will most likely be penning anathemas on surveyors, and local authorities, for the next issue of the local "Thunderer." But this is a digression for which the author would apologise.

To consider, then, the question of road-watering from a practical point of view, we must first ascertain the quantity of water required in order to lay the dust effectively; secondly, we must spread the water by means of the most effective appliances; and thirdly, we must purchase the water on the most advantageous terms.

The first of these topics, the amount of water required, admits of much discussion. It is impossible to formulate a rule, because the question is affected by such a variety of elements, of which we may enumerate the following: the nature of the materials forming the surfaces of the roadways; the condition in which the roads are kept, as regards cleanliness, for the more dust allowed to remain the more water will be required; the aspect of the streets, and the absence or otherwise of trees and other shade factors; the wetness or reverse of the particular locality and its peculiar requirements; lastly, the important question of finance.

We may divide roads into two broad classes; the anti-dust, such as those paved with wood, asphalte, granite, &c.; and the dusty, where the surfaces are macadamised or are formed with flints, &c. The former naturally require much less water than the latter class.

It is usual in the Metropolis to allow 130 days as the average period during which the streets are watered. In 1884, the streets in the author's district, Wimbledon, were watered on 132 days. At fashionable seaside resorts, such as Brighton and Hove, watering is performed all the year round when necessary.

The rainfall exercises a considerable amount of influence on the question, and approximately, it will be found that on days when ·08-inch and upwards falls, watering will not be required, although it may sometimes occur that watering will be necessary two or three hours after the cessation of a heavy fall. Careful observation will prove that a fall of ·04-inch of rain will lay the dust in a well kept macadamised road, and also effect a very slight washing, a little water running into the gullies. That amount of rain is equal to ·187 gallon per square yard, which is also the usual amount spread by vans and carts. In seasons of prolonged drought, light washings are much to be approved, in order to remove some of the absorbed filth, and to sweeten and refresh the atmosphere.

The author ordinarily spreads one gallon of water over 5·2 square yards, or ·192 gallon per square yard at each watering. Last season, the roads were watered on 132 days, and 2¼ times each day; thus, each super yard was watered 298 times, and 298 × ·192 gallons = 57·216 gallons per yard. A mile of road, 24 feet in width between the kerbs, contains 14,080 square yards, and 14,080 × 57·216 = 805,601 gallons, the amount used per mile. A reference to the appendix will, however, show how widely the figures differ as regards other districts. According to Mr. Booth Scott, 35,065,370 gallons were used on the St. Pancras roads in 1883; the mileage being about 80. The water was used at the rate of 438,300 gallons per mile. At Hove, Mr. Ellice-Clark used last year about 1¼ million gallons per mile of 14,080 square yards. At Norwich 514,300 gallons were used per mile (width not stated), and at Wellingboro' 228,400 gallons. The wide variations are thus sufficiently indicated, but in residential districts like Wimbledon, it may be safely assumed that on an average ⅘ths of a million gallons per annum will be necessary, costing @ 9*d.* per 1000 gallons, 30*l.*, and at 10*d.*, 33*l.* 6*s.*

With regard to the second part of the subject, that of the distribution of the water, we have to consider four methods, as follow:—Brown's; the Paris; the hose-reel; and the tank or van.

Brown's system will be very shortly described, as its details have often been published, and it is not likely to be widely adopted. A channel 2½ inches in width is formed at the back of each kerb, in which is laid a lead pipe. At intervals of a foot, a small shield, having suitable perforations, is fixed, and corresponding holes are bored in the pipe. The surface is then made good with asphalte; stop cocks are provided, and on turning on the water it issues in fine jets in the direction of the carriage way, thus effecting the desired purpose. Mr. H. T. Tomkins, Surveyor to the St. Mary-le-bone Vestry, tried the system, and reported as follows:—"While the water is turned on, pedestrians cannot occupy any portion of the kerb or roadway; that the jets rising 3 to 4 feet above the roadway may be a cause of inconvenience to the traffic; and that the effects of high winds when the pipes are laid on one side only (as in the case of narrow roads), would be to seriously interfere with the proper watering of the streets; that in very wide streets it would be necessary to water the central path with carts." The cost per mile is stated to be 832*l.* 6*s.* 8*d.* for a 40 feet road, and the cost per annum as follows:—

	£	s.	d.
One man 130 days at 3*s.* 9*d.*	24	7	6
Interest on outlay at 6 per cent.	50	0	0
Total	£74	7	6

And 74*l.* 7*s.* 6*d.* divided by 130 days is equal to 11*s.* 5*d.*, the cost per watering day, exclusive of water.

It is a question if the above estimate is correct, as if the money for construction is borrowed at 3½ per cent. per annum, 6 per cent. will mean a life of 25 years for the appliances, and nothing will be left for repairs. In the opinion of the author, the daily cost should be 16*s.* 3*d.* instead of 11*s.* 5*d.*

In what is known as the Paris system, the distribution of the water is accomplished by means of a series of short lengths of very light galvanised iron pipes, joined by short pieces of leather hose, thus allowing the whole length in use to be turned into any desired direction when mounted on the light trucks or carriages forming part of the system. A special distributor is fixed at one end, and the other being attached to a hydrant, water is applied in any direction, and in such quantities as may be desired within the limits of the machine. The apparatus is constructed in a very light and portable form, and is especially suitable for washing the paved surfaces of streets and alleys, also for ordinary watering, and in situations where carts or vans are inadmissible.

In 1850, Mr. Lovick made experiments in cleansing streets with the hose and jet, and the results may be found in Law and Clark's "Streets and Roads." With very low pressures, Mr. Lovick found that rather less than a gallon of water was necessary per superficial yard for effecting a cleansing, while Mr. Lee, of Sheffield, found with high pressures, one-third of a gallon sufficient. The record of an interesting series of experiments carried out in the City, may also be found in the same work. In those experiments, from 1·90 to 2·66 gallons per square yard, were used on asphalte, and granite pavements. The total average cost per cleansing was 29·88 shillings per 1000 square yards, and per annum, 40*l.* 6*s.* 6*d.* According to Mr. Lovick's results, the cost per 1000 square yards per annum was 20*l.* 16*s.* 8*d.* Of course, the cost per annum will vary with the number of operations performed during that period, and the cost of water must be added to the sums mentioned. Moreover, in such cases the term should rather be street-washing than street-watering; and, it is of great importance to the traffic that asphalte and other paved surfaces should be washed when in a moist, greasy condition, otherwise horses cannot traverse the streets with safety.

The complete apparatus used in the Paris system, may be purchased from Merryweather and other firms, at about 7*l.* 10*s.*

The hose-reel is a useful contrivance and may be seen in operation at Tunbridge Wells, Reading, Ramsgate, and elsewhere. Headley's machine consists of a large reel in a suitable frame, mounted on a pair of wheels. Flexible hose of the required diameter and length is wound on the reel. When in operation, one end of the hose is coupled to a stand-post or hydrant, the water passes through and is distributed by means of a special spreader. As the watering is completed, the machine is moved forwards, and the hose is unwound and lies on the ground. This last feature must militate against the adoption of the system in crowded thoroughfares.

At Tunbridge Wells, 11 reels are in use, and according to the information supplied to the author by Mr. Brentnall, "the system is very easy and simple in application and very superior and preferable to carts. The latter are only used when the pressure, which varies from 40 to about 326 feet, is not equal to the work. The hose is of indiarubber, 3-ply, 1 inch in diameter, and lasts five years. The water is taken by means of a stand pipe of special construction, from Bateman and Moore's fire cocks, which are placed 75 yards apart. (The stand-post is by Beggs & Co., Southwark.)

The cost of a complete apparatus is as follows :—

	£	s.	d.
No. 3 hose-reel (Headley and Edwards)	15	15	0
36 yards, 3-ply, 1-inch hose	6	15	0
Unions	0	6	0
Special standpipe	2	4	1
Total	£25	0	1

The average work performed per day of 10 hours by a cart, and by a hose-reel, is as follows :—

Man, water-cart, horse :—	Man, boy, hose-reel :—
19,860 superficial yards.	19,860 superficial yards.
7,700 gallons water.	9,100 gallons water.
9*s.* cost, inclusive of repairs, renewals, &c.	6*s.* cost, inclusive of repairs, renewals, &c.

The above areas are watered twice daily, therefore the quantity of water spread per super. yard at each watering will be $\frac{7,700}{39,720} = \cdot 193$ gallons in the case of the cart, and $\frac{9,100}{39,720} = \cdot 229$ gallons in that of the hose-reel.

According to Mr. Parry,* a hose-reel will water twice a day an area of 237,40 yards at a cost of 6*s.* 3*d.*, not inclusive of water, which was spread at the rate of ·65 gallons per super. yard, or 1·30 gallons per yard for the two waterings. (Mr. Boulnois erroneously assumes that 1·30 gallons were spread at each watering.)

If these charges were reduced to a rate for once watering an area of 1000 square yards, water costing 10*d.* per 1000 gallons, the figures will be as follows :—

		d.		*d.*
Reading	Headley's reel,	8·08	Cart	7·23
Tunbridge Wells ..	„	4·11	„	4·64

No details of pressure are given as regards Reading, but as it is stated that at Tunbridge Wells the cart is used where low pressures only obtain, the comparison must not be taken as conclusively proving the economy of the hose-reel.

With regard to carts and vans, the published information is not reliable, as the van is unduly puffed, while the cart is a much maligned, though useful article. We are told a van will spread so many feet wider than a cart, and use much less water, and so on. But, obviously, the width watered depends, not so much on the mere size of the tank, as upon the head of water on the distributing pipes, and the sufficiency of these to allow the full force of the head to be utilised. The velocity of the issuing jets, and, approximately, the distance to which the water will be projected, varies as the square root of the head. The distance is also influenced by the size of the holes, and by the direction in which they are drilled; also by the height of the distributing pipe above the surface of the ground, and there is no reason why a van should water a greater width than a cart if the latter is properly constructed. An interesting diagram of the paths of jets may be plotted, say under heads of 2, 3, and 4 feet, issuing at different degrees of obliquity. With the spreaders fixed 2 feet above the ground, an angle of 40° will give the greatest projection. Under such conditions, a theoretical width of 25 feet may be watered with a full head of 4 feet, while with the head, due to the tank being nearly empty—say of 2 feet—a width of 16 feet only is watered. In practice, the author finds, taking the mean of several vans, that the widths are 18 feet when full, and 12 feet as just empty. The resistance of the air breaks up the jets, which, in consequence, do not reach to nearly the theoretical width.

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* 'The Municipal and Sanitary Engineer's Handbook' (Boulnois).

The variation in the width watered as the van becomes empty, is well known to surveyors, and attempts have been made by means of valves to regulate the width. But, in order to do so, the width due to the minimum head can only be maintained, and the loss of time consequent upon the throttling of the water would not compensate for any advantage thus accruing. A side spreader of complicated construction could be adopted also. In that case, the spreader must revolve slightly as the van becomes empty, so that the water issue in a horizontal direction at first, gradually changing until the finish, when it should issue at an angle of 30°. When the nature of the appliances necessary for effecting the object is considered, it will be admitted that no commensurate advantages will result from their adoption.

A considerable width of spread has been attained in Willacy's patent cart, by the adoption of horizontal, rotating spreaders, operated by the wheels of the cart, in connection with a chain driving band. As the cart or van proceeds, the spreaders revolve, throwing the water to a considerable distance on each side. It is stated that this apparatus will water a width of 33 feet (" Preston Chronicle"). The spreaders are also constructed with large holes for distributing sand on the streets in frosty weather.

The amount of work that may be performed per diem with a cart or van will be mainly dependent on the pressures in the mains, since the periods occupied in emptying and in travelling, both when empty and full, may, with properly arranged stand-posts, be reduced to a nearly common standard. With pressures such as should obtain in an efficient system of water supply, the vans of 460 gallons should be filled in 4 minutes at most, 6 minutes will be occupied in discharging the contents, and about 10 minutes in travelling full and empty, and in getting into position for re-filling; thus three van loads per hour may be distributed. With exceptionally good pressures, and close contiguity of the streets watered, the author has found that 96,000 square yards may be watered with 18,432 gallons of water per day of 10 hours; but the average amount of work performed in his district is the spreading of 13,824 gallons on 72,000 square yards, with a van, and 10,100 gallons on 52,600 yards with a cart; but with very low pressures, the difference between the amount of work performed by a van and by a cart will not be so great.

Although, as stated above, a van waters an area nearly one-third in excess of a cart, it uses a proportionately greater amount of water, and the total saving, as shown in the subjoined table, does not exceed about 16 per cent.

Mr. Parry gives the area watered with a cart as being 23,849 square yards, and Mr. Brentnall, 19,680, in both cases the areas being watered twice. The fair inference is, therefore, that in these cases the carts are used in conjunction with low-pressure mains.

The following details were furnished by Mr. Ellice-Clark, M. Inst. C.E.:—

STREET-WATERING AT HOVE, BRIGHTON, 1ST JANUARY, 1886.

Length of road watered with one van load of water .. 462 yards.
Average width .. .. 17 feet 9 inches.
Area = 2733·5 square yards.

Capacity of van 450 galls., $\frac{450 \text{ galls.}}{2733\cdot 5 \text{ yds.}} = \cdot 16462$ galls. per yd.

On the average, watering takes place on 245 days each year.
2733·5 yards super. × 40 van loads per day × 245 days = 26,788,300 yards super. watered once per annum.
450 gallons × 40 loads × 245 days = 4,410,000 gallons.

Cost.

	£	s.	d.
4,410,000 gallons water at 5*d.* per 1,000 gallons ..	91	17	6
245 days' horse hire at 8*s.* per day of 10 hours ..	98	0	0
Hydrants and maintenance	1	0	0
Water van, and ditto, as below	5	19	2
Total	£196	16	8

Cost of Van.

	£	s.	d.
Cleaning	0	3	4
Painting and paint	0	6	4
Repairs	1	5	0
Annual investment at 3 per cent. to produce 48*l.* 9*s.* in 10 years	4	4	6
	£5	19	2

"196*l.* 16*s.* 8*d.* ÷ 26,788,300 yards = ·001764*d.* per superficial yard each time of watering. These figures are for watering on a perfectly level road, and are the result of some years' working with 7 vans."

In this case, water costs 0·823*d.* per 1000 yards, and vans, labour, &c., 0·9410*d.* per 1000 yards.

In the author's experience, a van waters 2400 square yards each time of filling, spreading the water at the rate of ·192 gallons per square yard, the average width being 5 yards and the length 480 yards. The horses and vans are the property of the Board, the costs being as follow:—

	s.	d.
Horse, including stabling, fodder, shoeing, vet., harness, and 10 per cent. depreciation	4	0
Driver	3	6
Van, including every charge, allowing 130 days to the year	0	9
Total	8	3

A cart costs, with all charges, 7*s.* 10*d.* The watering of 1000 square yards once, costs 1·37*d.* with a van, and 1·78*d.* with a cart; the water at 10*d.* per 1000 gallons costs 1·92*d.*, and the total costs are: van 3·29*d.*, cart 3·70*d.* Although a van waters a much greater area than a cart, the total saving as indicated by these figures is only about 11 per cent., while the saving, not including water, is about 23 per cent.; in short, with dear water, the saving is proportionately less than with cheap water.

Mr. Tomkins found the saving to be 23 per cent. in the parish of St. George, and 20 per cent. in Marylebone (not including water). The City of London Board give 15 per cent. as the amount. Mr. Tomkins' experiments show that in his district a van may be filled 35 times a day, spreading 15,750 gallons of water; a cart 54 times, spreading 13,600 gallons.

Mr. Codrington* states, that according to Mr. Tomkins, a van will water 161,000 square yards per diem; but it does not appear from that gentleman's report that he made the experiment; if a van were mounted behind an express train, even that record might be beaten.

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* 'The Maintenance of Macadamised Roads,' p. 113.

The foregoing results may now be summarised. Water is charged at 10*d.* per 1000 gallons in preparing the table.

From an examination of this table, it would appear that watering by means of vans is undoubtedly the cheapest method. The favourable returns by Mr. Ellice-Clark are doubtless due to the excellent pressures in the Hove water-mains. Taking the author's figures, a mile of road (14,080 square yards), 24 feet in width between the kerbs, may be watered once at a cost of 3·86*s.* The number of waterings per annum, as before stated, is 298, or say 300, and 300 × 3·86*s.* = 57*l.* 18*s.*, the cost per mile per year, of which sum 24*l.* 2*s.* 2*d.* would be for the van, horse, and labour, and 33*l.* 15*s.* 10*d.* for water. This is rather more than the cost in many of the London districts, but of course, the exact cost will vary with the price of water; as an instance, in part of the author's district, the rate is 8½*d.* per 1000 gallons, and the rate per mile, taking the same basis as to quantity, is 28*l.* 14*s.* 6*d.* for water, the total cost being 52*l.* 18*s.* 8*d.* Some interesting figures as to cost may be found in the appendix; and the author would here express his thanks to those gentlemen who have kindly supplied him with information.

Spreading Apparatus.	Area watered twice per day in square yards.	Gallons spread per diem.	Quantity spread per yard each time, in gallons.	Cost per day ex. water.	Cost of once watering 1000 sq. yards ex. water.	Cost of water per 1000 yards at 10*d.* per 1000 gallons.	Total cost per 1000 sq. yards.	Authority.
				s. *d.*	*d.*	*d.*	*d.*	
Headley's reel	23,740	30,862	·65	6 3	1·58	6·50	8·08	Parry.
Cart	23,849	11,924	·25	9 5	4·73	2·50	7·23	"
Headley's reel	19,860	9,100	·23	6 0	1·81	2·30	4·11	Brentnall.
Cart	19,860	7,700	·193	9 0	2·71	1·93	4·64	"
Van	36,000	13,824	·192	8 3	1·37	1·92	3·29	Author.
Cart	26,300	10,100	·192	7 10	1·78	1·92	3·70	"
Van	54,670	18,000	·1646	8 7	0·941	*1·64	2·58	Ellice-Clark.
Cart	..	15,750	..	..	..	..	..	Tomkins.
Van	..	13,600	..	..	..	..	..	"

* At Hove the water really costs ·823*d.* per 1000 square yards.

With regard to the choice of the appliances for conveying the water from the mains to the vans, &c., the hose, with coupling for attachment to the fire hydrants, is a convenient and simple appliance, and water may be obtained at lesser intervals than in the case of the fixed stand-pipe; but the latter with its swivel swan-neck is the better appliance as a labour saver. The charges made by the London water companies, however, for its rent or hire—

about 2*l*. per annum—is much too high. In the best stand-post, the outlet to which the swan-neck is attached, is screwed to the 2½-inch fire brigade gauge, to admit of its use as a fire hydrant.

As may be seen in the returns subjoined, water for street-watering purposes is paid for in a variety of ways. The system that would commend itself as being the fairest to all concerned is that of paying for the quantity actually used, which is most accurately ascertained by placing a meter at each stand-post. A cheaper method is to place a tell-tale in each van or cart; but this may be termed an inferential method, not that all water-meters are positive measures. Tell-tales cost about 4*l*. each. At Bexley and at Walsall, a fixed charge is made for each van used, the rate being 50*l*. per annum in the case of the former town, and 30*l*. in that of the latter. Where water is charged for at a rate per 1000 gallons, the cost varies from 1½*d*. at Basingstoke to 1*s*. 3*d*. at Camberwell. In many of the London districts a sliding scale is adopted, the price varying with the height to which the water has to be pumped, elevated districts paying more than those at a lower level.

Pumping water by hand labour from wells into the vans would not appear to be an economical plan, as at Hampton a large saving has been effected by taking the water from the mains at 6*d*. per 1000 gallons, instead of hand pumping from the river, &c.

Sea-water is used with advantage, where available, for road watering. The soluble salts are left on the surface watered when the water has evaporated, and by taking moisture from the atmosphere or from the subsoil when required, humidity is maintained for a period dependent on the amount of the salts, and on the hygrometric conditions of the atmosphere.

The admixture of the chlorides of calcium and of sodium with water for road-watering has been the subject of a patent, the proportions used being 8 ounces to 16 ounces per gallon of water.

Mr. Boulnois* mentions that at Rouen chloride of calcium is obtained from the manufactories of pyroligneous acid. It is mixed with water for use on the roads, the solution making 30° Beaumé, and costing about ½*d*. per gallon. It appeared from experiments that 1480 gallons of the solution were equal to 5630 gallons of water. The cost of 1480 at ½*d*. is 3*l*. 1*s*. 8*d*.; and of 5630 gallons at 9*d*. per 1000 gallons 4*s*. 2·67*d*.; but, as watering with the solution lasted five to six days, and the expenses of spreading must be added, the ratio of cost will differ from that given above. The cost of spreading is about 8*d*. per 1000 gallons, and therefore

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* 'Municipal Engineers' Handbook.'

11·84*d.* must be added in the first case; and 3*s.* 9*d.* a day, for say six days in the latter, making, with the water 8*s.* per day, or 2*l.* 8*s.* per week, as against 3*l.* 2*s.* 8*d.* in the case of the solution. It would not appear, therefore, that there is any economy in substituting the solution for water where the latter can be procured at a reasonable cost.

APPENDIX.

Town.	Miles Watered.	Price of Water per 1000 Gallons.	Rent of Meters per Annum.	Remarks.
Aldershot	..	1*s.*	1*l.* 17*s.* 3*d.*	Watering March to September.
Aston-Manor	30	6*d.*	..	Eight carts, one van. Hydrants 3*s.* 9*d.* per year.
Ashford ..	6½	..	..	100*l.* a year for water. 107 days.
Bexley ..	9¾	..	..	50*l.* for each van per season for water.
Banbury ..	..	9*d.*	20*s.*	Standposts 20*s.* per year.
Basingstoke	5	1½*d.*	..	130 days. Carts and vans.
Barrow-in-Furness.	19½	10*d.*	..	Distribution 2*d.* per 1000 yds. carts, 1½*d.* vans.
Beckenham	..	1*s.* 2*d.*	2*l.* 2*s.*	Standposts 30*s.*
Birmingham	2,790,000 sq. yds.	4*d.*	..	1884, consumption 43,267,070 gallons. Quantity ascertained by means of tell-tales, one of which is fixed in each van or cart.
Brentford ..	2½	6*d.*	2*l.* 2*s.*	.. ..
Brighton ..	74 1,041,920 sq. yds.	5*d.*	..	8*s.* per day paid for each horse and driver. Distribution costs 27*l.* per mile.
Burnley ..	2	6*d.*	..	Cost of distribution 5*s.* per mile per day.
Burton-on-Trent.	35	10*d.*	32*s.*	Distribution 20*l.* 7*s.* per mile
Bloomsbury	11½ 220,104 sq. yds.	9*d.*	2*l.* 2*s.*	Average yearly consumption about 300,000 gals. per mile; cost of distribution 44·82*l.*
Camberwell	90	8½*d.*, 1*s.*, 1*s.* 3*d.*	2*l.* 2*s.*	Standposts 30*s.* per year.
Clerkenwell	19¾	9*d.*	2*l.* 2*s.*	.. ..
Croydon ..	81 1,140,480 sq. yds.	Own waterworks	..	Distribution (labour only) 19*l.* 15*s.* per mile.
Darlington	25	4*d.*	..	Roads watered 183 days.
Dudley ..	30	10*d.*	32*s.*	Cost of water 6·03*l.* per mile
Derby ..	70 741,620 sq. yds.	5*d.*	..	Cost of water 7*l.* 2*s.* 10¼*d.* per mile.
Enfield ..	7½ 111,600 sq. yds.	8½*d.*	..	Distribution 7*l.* 10*s.* per mile.
Farnworth	3	6*d.*	..	10,000 gallons per diem used.
Great Yarmouth.	36¾ 538,560 sq. yds.	1*s.*	..	Sea-water about to be pumped at a cost of 3¼*d.* per 1000 gallons.

Town.	Miles Watered.	Price of Water per 1000 Gallons.	Rent of Meters per Annum.	Remarks.
Greenwich	64	..	..	30*l.* per mile paid for water, inclusive cost 53*l.* per mile.
Hampstead	38⅓ 202,504 sq. yds.	1*s.* and 1*s.* 3*d.*	..	Total cost 43*l.* 6*s.* 4*d.* per mile.
Hanley ..	6 60,000 sq. yds.	8*d.*	..	Total cost 25*l.* per mile.
Holborn ..	..	..	..	Pay 2*s.* per 1000 sq. yds. per day, two waterings.
Hornsey ..	28½ 450,565 sq. yds.	9*d.*	..	Watering 165 days. Water 14*l.* 18*s.* 10*d.* per mile, distribution 29*l.* 9*s.* 4*d.*
Hove	..	5*d.*	..	Dealt with in paper.
Longton ..	..	7·74*d.*	..	Quantity ascertained by means of tell-tale.
Lambeth ..	..	8½*d.* to 1*s.*	2*l.* 2*s.*	Standposts 40*s.* Levels vary from 12 feet to 350.
Ipswich ..	32	8*d.*	..	Total cost about 1000*l.* a year.
Newcastle-on-Tyne.	37¼ 731,700 sq. yds.	..	..	375*l.* a year for water. Distribution 30*l.* per mile on macadam, 28*l.* on wood.
Northampton	30¼	1*s.*	24*s.*	Hire vans, drivers and carts, at 9*d.* per hour.
Norwich ..	35	6*d.*, 7*d.*	48*s.*	Water last year cost 450*l.*
Over-Darwen	35	5*d.*	..	Distribution 7*s.* 6*d.* per mile, limestone; 6*s.* setts.
Portsmouth	77	6*d.*	..	.. ..
Rochdale ..	35½	7*d.*	..	Tell-tale in each cart. Water taken from fire plugs.
Rowton-Regis.	3¾ 52,800 sq. yds.	1*s.* 2*d.*	32*s.*	Pay drivers 4*d.* per load. Tell-tales used.
St. Mary-le-bone.	844,484 sq. yds.	9*d.*	Own	Distribution by contract, 5*s.* 9*d.* per 100 sq. yds.
St. Pancras	84	9*d.*	2*l.* 2*s.*	150 days, 1883, 35,065,370 gallons.
Southport ..	45	5*d.*	32*s.*	.. ..
St. James ..	13	¾*d.* sup. yd.	per year	Vans 10*s.*, carts 9*s.* 6*d.* per day.
Streatham ..	24	8½*d.* and 1*s.*	2*l.* 2*s.*	Water and meters 26*l.* 8*s.* per mile. Total 65*l.* 5*s.* 6*d.* per mile.
Tunbridge Wells.	22 300,000 sq. yds.	1*s.* 4*d.*	..	Dealt with in paper.
West Ham	52	9*d.*	2*l.* 2*s.*	Total cost 53*l.* 9*s.* per mile.
Willesden ..	18 286,353 sq. yds.	1*s.* 6 per cent.	2*l.* 2*s.*	Total cost 57*l.* 10*s.* per mile.
Winchester	17 248,960 sq. yds.	..	..	100*l.* per annum for water. Horse and driver 6*s.* 3*d.* per day.
West Bromwich.	39 548,912 sq. yds.	10*d.* to 1*s.* 2*d.*	32*s.*	.. ..
Wallesley ..	22 309,000 sq. yds.	7*d.*	..	Cost per mile 78*l.* 12*s.* 3*d.*
Whitechapel	16,482 sq. yds.	9*d.*	2*l.* 2*s.*	Cost 1*s.* per month per 100 sq. yds.

DISCUSSION.

Mr. Gordon, after some introductory remarks, said: Mr. Willacy's water-cart covers easily 30 feet; and therefore I find we can water our broadest roads, with one exception, with that water-cart, going up the centre. That is an immense advantage, and it does more than that—it spreads the water much more evenly. The reason why I looked out for a better water-cart was because our ordinary water-carts left tracts of the surface unwatered. This Willacy's cart, however, covered, with one load of 286 gallons of water, a road 286 feet long and 30 feet wide, or an area of 2266 square yards; being 100 gallons for 792 square yards. The old pattern of cart which we used in Leicester held 228 gallons ordinarily, but, when actually filled, 250 gallons. One of those carts covered a road of 750 feet by 13½ feet, or 1142 square yards. Therefore 100 gallons only covered 571 square yards, as against the 792 covered by Willacy's cart with the same quantity of water. Willacy's cart covered with 100 gallons 58 per cent. more of surface. But then you will readily see that the advantage does not cease there; that while Willacy's cart has covered the whole width of the road, the other cart, travelling 750 feet, has only covered half the area, so that you get it both ways. It covers 58 per cent. more surface; and it does the work with the same quantity of water, and covers a larger surface in something like three-quarters of the time, so that it is evident that it possesses immense advantages over the ordinary water-cart. It struck me therefore that Mr. Crimp in speaking of Willacy's manufacture was not aware fully of its value. When I first made inquiry about it, I found that it was not very well spoken of where it had been tried: but I have inquired since, and I could furnish a list of places where that cart is now being adopted. I am very anxious to get information from every one using it, so that we may really know what is the value of the apparatus attached to this cart in other towns. It is evidently being more recognised. I was perfectly astounded when I saw what it could do. I find from inquiry of Mr. Willacy that the first cart that was manufactured of this kind was made in 1880; another was made in 1881; in 1882–3 there were four made; and in 1884 there were four more made, while in 1885 seven was the number sent out. In Bradford they were evidently so satisfied with the one they obtained in 1884, that they have now eight of them at work. The Bradford authorities ought therefore to have a most excellent experience of its utility. In 1885 the Leeds authorities ordered one, and have I understand ordered nine more this year. I have a full list furnished me by the inventor. The cost is 47*l.* 10*s.* each. This cart covers such a large surface, that if you were going down a street of less width than 30 feet, you could not have the two centrifugal wheels working at the same time. You would have to take it on one side close to the kerb, and then it would cover with one of the centrifugal arrangements or half its power a width of 18 feet; and therefore in crowded thoroughfares, unless you can take a special time when there is no traffic, you must do it at twice. But I may as well say that in our greatest thoroughfare in Leicester we use both centrifugal arrangements; and we cover the whole road, even when the traffic is at its height. The tramcars catch the water, but it is shut off instantly that any horse shies at the water. While I believe the arrangements are as yet not perfect, still I believe that they are so perfect that with a little further improvement they will meet all the exigencies of a crowded thoroughfare.

Mr. Samuel Dyer: I was anxious to have some information respecting this cart of Willacy's. In the place where I have come from we have not used sea water, because we have been enabled to get other water at 6*d.* per 1000 gallons. I wish to know whether the salt which remains upon the surface of the street was not objectionable when the street gets dry?

Mr. Gordon: I was at the Yarmouth meeting recently. The sea water is there used, the surveyor having carried out a complete system of water supply for its use for street purposes. He showed us the salts lying upon the surface of the road after the water had dried, and stated that in his opinion the use of sea water for street watering was a virtue rather than otherwise. It kept the road moist for a longer time than ordinary fresh water. There is no complaint whatever from the shopkeepers.

Mr. J. P. Spencer: I should like to add an experience of quite ten years in the watering of streets with sea water. The question need not be entered upon at any great length, because it is so few places in which its use is at all applicable. I can assure those who are contemplating using it for this purpose, that during the period it has been used constantly, in no shape whatever has it been possible to substantiate any objection to it. On the contrary, there are many benefits and advantages which have been found to accrue from its use. The specific gravity of the salts, apart from and in addition to its absorbent qualities in renewing the moisture of the road, have the effect of keeping down the dust. It very soon puts a glaze upon macadamised roads, while upon the joints of setts it is very advantageous. I am sorry, not anticipating a discussion on this matter, that I am unprepared with any statistics, but I believe some very interesting information may be obtained upon that point. I am quite sure the salt water reduces itself to a minimum as far as the cost is concerned; in fact, 50 per cent. reduction over ordinary fresh water. Such a system, if properly carried out in any place within reach of the sea, would amply repay itself to any authority who would adopt it.

Mr. Gordon: It may be interesting to know that this same kind of cart is used for sanding roads. I have, indeed, one of that kind in use at Leicester. We have been accustomed to send out carts with sand to be spread by hand from the cart; and when I had to look out for something better I secured this cart, which does admirable work, just as it does for watering the streets. I find they have been trying it in other places for this secondary purpose. You can cover 30 to 40 feet of surface with a layer of sand; and it can be done so quickly, that you may cover miles before the people are up and the shops are open.

Mr. R. Vawser: I have no water-carts under my charge; but when we were in Bradford, one of these carts watering the streets and another used to sand the streets, were at work, and gave great satisfaction to all the Members who were present. Indeed, they considered it a very great improvement on all previous methods of sand and water distribution.

The President: In closing the discussion I may remark that owing to Mr. Crimp's absence we are placed at a considerable disadvantage. But no doubt there will be more queries sent up to the Secretary in writing, which Mr. Crimp could reply to. There are one or two matters which I can speak to in reference to the experience at the Bradford meeting with respect to these carts. They were exceedingly well pleased with the sand distribution, and a very nice layer of sand it was. The water-cart seemed to send a great deal more water than was necessary, but that difficulty, I believe, could be adjusted and regulated. However that may be, it was not regulated the day on which we were there. In Liverpool some years ago they tried the salt water for street-watering purposes. There was, however, a strong prejudice against it on the part of the shopkeepers. They asserted that the salt would injure the goods if it became in any way connected with the atmosphere in the shops. In Liverpool a series of mains would have to be laid down to make the system at all useful. When you consider that water costs 8*d.* per thousand gallons, 3*d.* for a two-wheeled cart, it is very clear that the cart must not travel far to save this 3*d.*; for the simple reason that you can soon spend that sum in time. There was one point I did not clearly gather from Mr. Crimp's paper. I do not see how by the use of a hose-reel and supply hose the water used was to be calculated upon if supplied by the water company. Some years ago we tried Hedley's reel, but it was not successful. The experiments perhaps could hardly be said to be fair, but the difficulty was caused by the water company. There was a great objection to the inferential meter, because they did not consider it was sufficiently accurate for payment to be governed by it, while the use of a positive meter would add great weight to the apparatus to be moved about. We tried it in Market Square, but it was a matter of great difficulty to keep the traffic off it. And, I repeat, the experiment altogether was not a good one. We do not profess in Hanley to carry out the watering of the streets to the extent it was done in many other towns. The cost was only 3*l.* per annum for each 1000 of the population; and therefore you will agree with me that we do not make any pretence to water the streets to the extent it ought to be done, when compared with Leamington, and residential towns in the south of England. In the appendix to the paper, the author has got down one place where the population is much less than it is in Hanley, and where they yet watered 450,000 square yards of road surface. That district, however, was almost entirely residential. It would be very interesting if the Members would communicate with the Secretary, giving the expense of the water, together with rateable value. Here we have the very greatest complaints, indeed, about the water. I should say that never on a dry dusty morning do I fail to receive a letter from some one complaining of the inadequacy of street watering. I live on a road which for five years has never seen a water-cart. The dust is so great, and the traffic so continuous with narrow-wheeled carts, that any attempt to water the thoroughfare satisfactorily would mean an enormous expenditure—and for that reason there was no attempt made to water it. In the central streets, where the shopkeepers have their goods exposed, the principal street watering was done.

Mention has been made of chloride of calcium. Very good results have been obtained from its use in the way of preventing water drying up quickly; but it played great havoc with the carts and distributors. The advantage is simply that it saves a little water, but by using a little more water you would get the same result at the same cost without doing damage to the iron fittings. There was one point about the vans. We find in this hilly district that a four-wheel van is of very great advantage.

Mr. Gordon: You mention that at Bradford you thought there was too much water being used. I find that one-eighth of a gallon covers a square yard with that cart; and with no other cart can you gain the same results.

The President: While I was exceedingly pleased with Willacy's cart, and think there is a great hope for it in the future, at the same time what we saw was a flood.

Mr. Gordon: Oh, but there was something wrong with it.

The President: I will move that a vote of thanks be sent to Mr. Crimp for his valuable paper on road-watering, regretting his inability to be present.

Mr. Gordon: I second it.

The vote was then put, and carried with acclamation.

CORRESPONDENCE.

The Author regrets that he was unable to be present at the meeting at Hanley. Mr. Gordon's remarks are chiefly directed to the respective performances of a Willacy's cart and one of the ordinary description. With Willacy's patent spreader, 1 gallon of water was spread on 7·92 yards, and with a cart 5·71 yards were watered, or ·126 and ·175 gallons per square yard were used respectively. At the time of writing the paper, the author had not seen a Willacy's van at work, but since then, through the courtesy of Mr. Meade, he has seen one at Highgate. He can confirm Mr. Gordon as to the width watered, &c., but he is strongly of opinion that the quantity spread per super yard is not sufficient. One of Bayley's, one of James's, and Willacy's, were started on a broad road side by side; the day was very hot, and the road a macadamised one; there was no doubt but that James's did the best work; Willacy's did not spread nearly sufficient water, although that defect can be remedied. Possibly the streets in Leicester are pitched, or paved.

With regard to the President's remarks, in cases where the hose-reel is used, it would doubtless add a great deal to the cost if meters were fixed at each fire plug, which appears to be the only feasible plan, unless water is paid for at so much per mile, or per square yard watered.

In conclusion, he is glad to find salt water a success when used for road watering, as at Yarmouth and other places, since sea-side towns can adopt a salt-water supply, when hardly pressed by the water companies.

THE REFUSE DESTROYER AT NELSON.

By WILLIAM DENT, C.E., Nelson-in-Marsden.

The destruction by burning of town's refuse is a subject which has already received such an amount of care and consideration from the Members of this Association that I venture to think that it will not be an easy matter to bring before you any very marked improvement upon the methods already adopted.

It is not necessary for me to make more than a passing allusion to the careful and comprehensive efforts which have been made—with a great amount of success—to deprive town's refuse of its offensive character, and to the very large sums of money which have been expended upon the work. What I now more particularly wish to draw your attention to, is the fact that small towns having a population of from 10,000 to 20,000 persons are unable, or do not as yet seem disposed, to supply themselves with any apparatus whatever for this purpose. To see the work carried on with a certain degree of completeness and economy we have to proceed to Leeds, Bradford, Birmingham, or other towns of vastly larger size. Is it not a fact that an immense number of smaller towns than these possessing an apparatus for burning refuse, produce refuse which does not differ materially from that produced by the larger towns? Though less in bulk, it is certainly not less offensive in character, and should therefore, so far as the sanitary aspect of the matter is affected, be subjected to the same mode of treatment in the one case as in the other.

Before proceeding to describe the destroyer built at Nelson, perhaps I may be allowed to give a word of explanation of our position, and the reasons which induced me to bring it under the notice of the Members of this Association. Nelson is a small but rapidly increasing Lancashire town, situated 3½ miles from Burnley, 28 miles north-east of Manchester, and about 25 miles due west from Bradford. We have a mixed industry in weaving cotton, woollen, and silk fabrics for the London, Bradford, and Manchester markets. It has now a population of about 16,000, and rateable value about 40,000*l*. The increase in the number of occupied

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houses which has taken place within the last five years shows an increase of population at the rate of about 10 per cent. per annum, which is being steadily maintained. We are in the neighbourhood of other populous districts, and are bounded on the east, west, and south sides by the urban districts of Colne, Brierfield, and Trawden respectively, and on the north by the Pendle Water, which flows through the Calder into the Ribble. It will therefore be seen that we are under some obligation to dispose of our refuse in the least objectionable manner.

The disposal of the contents of ashpits (of which 3503 cart-loads were removed during the year 1885) is a matter which has not hitherto created very much concern either on the part of the Local Board or the public. In common with many other towns of similar size and population, and probably not a few of much larger size, we find that very convenient but at all times objectionable system of tipping ashes in the state in which they are taken from ashpits (wherever there can be found conveniently near, a plot of waste or low-lying land, or disused pit or quarry), to be nearest in accordance with local views of utility and economy. This system of tipping all kinds of refuse cannot go on for an indefinite length of time, the site of a "tip" becomes in course of time a site for dwelling-houses; and here I may allude to the restrictions placed upon local authorities who have the Model Byelaws. No. 9 provides that "It is unlawful to erect a building upon a site impregnated by fæcal, animal, vegetable, or other objectionable matter." I have little doubt that there are a number of towns ready to discontinue tipping, at all events the more objectionable kind of refuse, and to undertake the erection of some apparatus of a size corresponding to their requirements, if it could be shown that the refuse can be burnt for a combined cost of working and maintenance which would not be found to press too heavily upon the rates.

It is well known that there is produced in all towns refuse of a far more objectionable kind than that from ashpits, namely that from fish, fruit, and poultry shops, slaughter-houses, and markets; and for some time past we have in Nelson had considerable difficulty in getting rid of this refuse without creating a nuisance. The Local Board therefore, having decided upon the expediency of themselves dealing with this class of material in particular, took for a term of years a small plot of land for the purpose of erecting the most suitable contrivance which could be found for depriving it of its noxious character. After waiting some time the Local Board entered into an agreement with the patentees of the destroyer, the plans and a model of which are now before you, and the structure has been erected by them in a thickly populated part of the district. The flue from same is connected to a chimney previously in existence, only 20 yards in height, which, however, the Local Board have undertaken to raise to 40 yards when required. For purposes of comparison, the patentees suggested that the destroyer should be tried with the chimney at its present height.

The apparatus consists of a substantially-built brick structure, containing four furnaces, three of these being refuse furnaces, and the fourth for burning the vapours.

The refuse is tipped upon the platform, as near as possible to the inlets at the top of drying hearths (which are about 9 feet above the floor in front of destroyer), from which it is easily transferred to the cells.

The size of three refuse furnaces is 10 feet long by 3 feet wide, of which 3 ft. 6 in. × 3 ft. is occupied by the grate-bars. The construction of No. 1 furnace (referring to plan) is that of an inclined plane with shelves or apertures formed in the drying hearth, so formed as to allow air to pass through the refuse from the opening at back of ashes grate, to facilitate the drying and combustion both of the refuse and the vapours given off in the state of incipient burning. From this inclined plane or drying hearth, the material is brought forward by gravitation, and some assistance from the stoker's rake direct to the grate-bars, where it is brought in contact with the hottest part of the fire and withdrawn at the front either as clinkers or fine ashes. In No. 2 furnace the floor is formed about level with the grate-bars, the full width inside, and in the hollow space thus formed by the inclined hearths of furnaces Nos. 1 and 3, it is proposed to place, mixed with ordinary ashes, material of the least combustible kind, such as wet garbage, excreta, and slaughter-house refuse, which would be left to form its own incline to the grate-bars. No. 3 furnace does not materially differ from No. 1, except with regard to its fewer air-inlets.

It will be noticed that at the sides of each of the furnaces there are placed two oblong doors, each measuring 18 inches by 6 inches. These communicate with channels or cavities in the wall, and are for the purpose of providing a continuous supply of highly heated air to the furnaces, into which it enters from openings in their side walls, the upper channels discharging their heated oxygen to the near parts of the furnaces, the bottom ones being carried on an incline to the extreme back, where they are discharged amongst the refuse drying or only just brought in contact with the fire. The value of these inlets will, I think, be readily seen. They materially promote the combustion of both refuse and vapours, and help to lessen the time required for consuming the refuse and forming clinkers.

The furnaces are made specially narrow in our case, in order that the refuse may be divided into classes, and for the purpose of utilising the heat generated by the most combustible refuse in No. 1 furnace for drying and preparing that which is less combustible, the heat and gases from No. 1 furnace passing over that of Nos. 2 and 3, and that from No. 2 over No. 3. After passing No. 3 furnace, the vapours descend a flue, the bottom of which forms a chamber containing water to the depth of about 6 inches. On this water, there can be used if found necessary a small jet of petroleum, or any cheap and suitable unrefined oil, which would be allowed to run automatically and burn over the surface of the water, arresting and depositing in the water any particles that may escape from the furnaces, and also helping to consume the gases. It has been suggessted by the patentees that the flame from this small jet of petroleum could be effectually distributed over the whole area of the flue by a small jet of steam discharged at right angles. Provision is made for drawing off the liquid portion contained in the well, at any time, and for removing accumulations of dust and solid matter deposited by the current of heated gases. It might be found necessary to use the means afforded by this chamber in burning very offensive or infected substances, but an arrangement could be made whereby the vapours would be turned from the three refuse furnaces into the fourth furnace direct, which being heated with coke, or selected portions of refuse, becomes an incandescent mass which yesterday gave a temperature of over 600°.

The area of this furnace is regulated to that of the others, and into, over, or amongst this the gases must pass before they can reach the chimney-stack.

The necessity of providing a fire with a very high temperature through which the vapours given off in the earlier stages of burning must pass before they reach the chimney, will, I think, be admitted, although the cost of maintaining a hot fire for that purpose will materially increase the working expenses.

The appliance is simple in construction, strongly built, lined with fire-bricks, and braced with stout iron girders firmly bolted together. The only ironwork subjected to the intense heat of the furnaces being the grate-bars and bearers. The cost of repairs is therefore expected to be slight.

The capacity of each refuse cell is about 2 cart-loads, and from a 24 hours' trial made yesterday I have formed an estimate that the apparatus will dispose of about 1½ loads per cell per day of 24 hours, or 1638 loads per annum. The total cost, exclusive of chimney, will not exceed 450*l.*, and I do not expect the cost of burning to exceed 1*s.* 5*d.* to 1*s.* 6*d.* per load. This does not include any allowance for fuel to No. 4 furnace.

I regret that the apparatus has not been tested for a sufficient length of time to enable me to give the exact cost of burning. Six weeks ago I had the impression that there would be no difficulty in doing so, but various alterations by the patentees prevented it, and it will also be necessary, I think, to increase the height of the chimney before it can be said that the apparatus has been fairly tried.

DISCUSSION.

The PRESIDENT: Would the author of the paper tell us what are the advantages over the existing methods? The Association has seen other methods in operation in Nottingham, Blackburn, Bury, Burnley, and Ealing. Respecting the claims of recent inventors, it would be useful to know whether those differences more recently mentioned supersede or are in any way better than the others we have seen. The cost, as I gather, is not all the advantage of which the invention consists. As regards myself, I am entirely on the inquiring side. We have not got a destructor here. A great element of cost of an apparatus of this kind is the chimney-stack, which, at present, at Nelson, I understand, is simply borrowed.

Mr. DENT: I do not know that any destructor now in the market has this furnace entirely devoted to the object of destroying vapours. It has, however, come to my knowledge since writing this paper that there is a furnace at Ealing devoted to that purpose. Very important things in connection with it are the air-inlets. We have here [referring to model] a number of oblong doors in front of the destroyer, which are for the purpose of admitting air into and over the refuse, and these are distinctly additions to any apparatus I have seen myself. The effect of these air-inlets is to obtain an intensely hot body of fire at the points where they enter the furnaces, and it is expected that the clinkering process will be accelerated thereby. I do not know that there is anything new in the way the material is brought into the furnace. It is simply a repetition of other furnaces we have seen. But in regard to these air-inlets and also in regard to the furnaces for burning the vapours so far as I knew at the time I gave notice of this paper they were quite new.

Mr. J. CARTWRIGHT: I have listened to this paper with great interest, having been one of the pioneers in advocating this mode of disposal of night-soil; at the time I recommended my Council to adopt this method of disposal there was only one apparatus before the public. It has occurred to me that the expense incurred in the disposal of night-soil by the one we adopted is so great that there is urgent need of a cheaper method of producing the result aimed at. By covering the ashpits and instructing the people to keep out the slops, we get the material so dry as to be enabled to destroy the amalgamated refuse. The destructor is that of Messrs. Fryer & Co., and though it does its work well it is a rather expensive one. The cost of its erection, from 3000*l.* to 4000*l.*, was rather large, but some allowance must be made for the larger chimney and flues than required for the number of cells. I am not able to state the exact cost per load, having no figures with me; but it is a few pence in excess of that stated by Mr. Dent. Our thanks are due to Mr. Dent for bringing this subject to the notice of the meeting. It is desirable that we should be informed of any improvement, for it is one of those matters that should be pressed upon our several Boards, so soon as we are satisfied that the results are such as to warrant the expense. I believe there is no better method of getting rid of the night-soil and house refuse than by destroying it by heat. Our obligations are due to Mr. Dent, and I beg to move that the thanks of this meeting be given to him for his interesting paper. I hope that at some future time we shall have the benefit of Mr. Dent's further experience. The reading of the paper at this time shows that there is a desire on the part of Members to give the earliest information; and though Mr. Dent's paper does not give all the information desired, we appreciate it none the less.

The PRESIDENT: I am sure we are very much indebted to Mr. Dent for the trouble he has been put to in bringing plans and models. I have therefore very great pleasure in putting the resolution to the meeting, that its best thanks be given to the author of the paper.

The resolution was then put, and carried unanimously.

Mr. Gordon: I was in hopes that we had gentlemen with us who had had more experience with these destructors. What we have heard from Mr. Cartwright is only a part of the knowledge gained with regard to these destructors. There has been an attempt, to which you have alluded, to cheapen the cost for smaller towns, and even for larger towns, with the beehive destructor. You started by asking a question which I should like to follow up. I am of an inquiring turn of mind on this matter, because we have not at the present moment a destructor, but have for years been thinking about erecting one. However, the cost has stood in the way up to the present time. As, however, we are likely to erect a destructor, one would like to know the best methods. We did turn attention to the beehive. I was instrumental in erecting a beehive destructor for the Corporation of Leicester for experiments; but I am sorry to say that the experience we then gained was anything but satisfactory. We were followed by Richmond; and though I am not quite sure, I am afraid their experience has not been very much better. It occurs to me that this new destructor had something in common with the beehive. I should like to know whether it is so or not? I am not quite clear; but, Mr. Dent, is it your own invention?

Mr. Dent: No: it is a patent, belonging to Messrs. Thomas Bertwistle and James Richmond of Burnley.

Mr. Gordon: That of course only shows that the gentleman who is connected with this patent must have finally come to the conclusion that the beehive is not so satisfactory as he hoped it would be. There appears something about this which requires explanation. The cost, 450*l.*, is a very small one, and puts it within the reach of the smallest communities; but the amount of work it is expected to do is very small—six loads a day for three cells. The calculation that 1*s.* 5*d.* per load as the cost of destroying refuse is still a very large one; and I am afraid it does not represent really what the cost will be, because in the first place the cost of the chimney is wanting, and I am not quite sure how you are going to get your refuse up the tip. Is there going to be an inclined plane, as in the case of Fryer's destructor?

Mr. Dent: Yes.

Mr. Gordon: It must materially increase the cost, and therefore whilst I am sure we are very glad to have any gentleman coming forward with new matters of this kind, so that we may investigate for ourselves, on this occasion that information is not complete. I mean that Mr. Dent has not completed his destructor, and cannot therefore give us the actual cost of the destruction of the refuse. I should like to know also what the residue is likely to be from a destructor of this kind? Supposing you put six loads into these three cells, how much of those six loads do you actually destroy? Will it be less than in the case of Fryer's destructor? You are not destroying the whole of the six loads; you are only destroying a percentage of them. There was another point which also struck me. Mr. Dent used the word "destroyer," and seemed to avoid the word "destructor." Has he had any notice from the firm claiming to be the original inventors, signifying that he is not to use that word, because it is an infringement of a patent right? I had a notice of that kind. I do not gather from Mr. Dent whether there was any fuel required in this destructor, or whether the refuse which he uses and is to destroy is after all the fuel. In the case of the beehive destructor we know very well that it requires a certain amount of fuel to keep it going. If it should be so in this case, it of course will have to be taken into account in calculating the cost of the destruction of refuse. I hope that when Mr. Dent has got this destructor into proper use, he will give his attention to the various points I have enumerated, and which may be further amplified by other Members, and that we may have on some future occasion full statistics with regard to the value of such a destructor. I must say that there is a want of that kind in regard to the destructors now in use. I have found it difficult to get reliable statistics, and therefore hope we may hear more of this subject, and that it has not turned out to be the failure as I think will be admitted the beehive destructor has been.

Mr. Eayrs: I notice in the paper Mr. Dent mentions something about providing fuel in the shape of coke. I should like to ask whether it is necessary to use coal, coke, or any other fuel to keep it going, and if so, why the cost has not been included in the estimate. Is the cost of fuel included in the estimate of 1*s.* 5*d.* per load? I have mentioned this because I have looked over the specification, and find one of the paragraphs saying that it was necessary to use coal for the purpose of keeping the fires going. That is an important factor. In a fire destructor you require no extraneous fuel whatever. When the furnace is once lighted, it goes on without any attention at all.

The PRESIDENT: I have not much to add to what I have already said, which was in the nature of guesses. It struck me that 1*s.* 5*d.* as the cost of destroying a load of refuse was rather high. It seems clear that two loads per cell must require fuel to keep it going; but my recollection of the Blackburn destructor is that it is self-supporting and kept going continually, that there was no fuel required, and that there was still heat enough for all other purposes. I was surprised to hear that the cost at Bury was a little over 1*s.* 5*d.*, but that may be accounted for by the fact that night-soil is included in it. I should think that an expense of 1*s.* 5*d.* alone for destroying refuse would be considered high, even in the south of England. The only other point is to ask Mr. Dent in his reply to state, does he think he will be able to supply data as to cost in time for the volume of our 'Proceedings'?

Mr. GORDON: And perhaps he would say what is the weight of a load?

Mr. DENT: Mr. Cartwright gives us some very interesting information about his own destructor. He says that his cost of destroying refuse exceeds by a few pence per load, that of my estimate. I do not ask you to accept that estimate as altogether reliable; I believe that I have stated a fair estimate. With regard to the royalty, that has not been fixed. This is the first of its kind, and I do not think the promoters of this destroyer have any idea of building another one until they have shown that this will perform the work that they expect from it. As to Mr. Gordon's first question as to whether it has any relation to the beehive. Mr. Bertwistle is the builder of the apparatus known by that name. Under his superintendence I believe the whole of these machines that exist have been built. He found that they were not doing their work satisfactorily, and therefore has given up his work in connection with that, and is paying his attention to the perfecting of this one, which he intends to place before the public as soon as he can satisfy himself of its economy and efficiency, and not before. Mr. Gordon asks about the percentage of residue. That will greatly depend upon the nature of the refuse. In Nelson, we expect the bulk to be reduced to about one-third—two-thirds to be lost in the consumption of the refuse: and when I say that, it should be known that we have a large proportion of incombustible fine ash in the refuse, before it is put into the destroyer. I was asked if it required any fuel. I saw on Wednesday night last, at ten o'clock, a fire in each of the three cells, which extended right up to the drying-hearth. It was an intensely hot fire, registering over 200 degrees of heat at the back, and was burning without any fuel beyond the small proportion contained in the refuse. If you saw the material, you would, I think, agree that the amount of combustible matter contained in it is very small in comparison with the bulk. The weight of a cart-load of ashes with us varies from 17 to 22 cwt. We could put more on if we had higher sideboards. With regard to fuel, from a certain class of refuse, it might be possible to screen as much material as would feed No. 4 furnace; but even if the fire is to be kept up by coke, I look upon it that the results obtained justify the additional expense of maintaining it, because the vapours which are generated in the early stages of burning are distinctly of an offensive and often dangerous character, and it is to render those vapours harmless and inoffensive that this furnace has been introduced. So that even if we do burn fuel, I say that it is burnt in doing something which is over and above the work done by any other apparatus which I have seen. You ask me if there is anything in the title. The patentees received a letter from Messrs. Fryer, claiming the exclusive right to the use of the word "destructor," upon receipt of which they at once dropped the term "destructor," and substituted that of "destroyer." Mr. Eayrs, in asking a question about fuel, states that the specification prescribes the use of coal. There is, however, no coal required, unless it be to enable the stoker to get up an active fire in a short time.

ON THE PUBLIC SUPPLY OF ELECTRICITY IN TOWNS AS AN ILLUMINANT.

By JAMES N. SHOOLBRED, B.A., Mem. Inst. C.E.

When, at the invitation of your President, I undertook to make a few remarks on the present position of this question—one of considerable importance to a body of Municipal Engineers, it was fully anticipated that an important change in the law bearing upon the subject would before this have taken place, as the result of the labours of a Parliamentary Committee of the House of Lords.

As, however, no such change has followed upon the inquiry just referred to, a certain amount of interest, which might otherwise have attached to this paper, must necessarily be wanting.

Still there are many points connected with the question, both at home and in other countries, which it will be of interest to touch upon.

The establishment in towns of centres of distribution of electricity seems to depend very considerably upon the facilities, or otherwise, which the law affords for such undertakings.

In this country they are subject to the Electric Lighting Act of 1882, and to the long series of technical and other regulations imposed by the Board of Trade in the Provisional Orders, which they exact. These conditions are found to be so vexatious, especially the terms of the compulsory purchase (clause 27 of the Electric Lighting Act) of these undertakings by the local authorities, as to render their commercial success very questionable indeed. This is proved by the fact, that of the Provisional Orders granted in 1883 (fourteen to local authorities, and fifty-five to private companies), not a single one has been carried into effect.

Contrast this with other European countries, such as France, Germany, Austria, Italy, and Spain, and more especially with the United States, in none of which countries are there any special legal regulations (other than an arrangement with the local authority of the particular locality, as to interference with the streets).

In all these countries, but particularly in the United States, such establishments for the public distribution of electricity are becoming every day more considerable, both in size and in number. In the United States, it must be borne in mind, that coal gas is about double the price that it is in this country; and therefore that electricity there enters upon the competition under more favourable conditions than it does here.

That the conditions imposed by the Electric Lighting Act of 1882, in the opinion of the late Government, the author of the Act, had proved unnecessarily vexatious and restrictive to its proper working, was admitted by it. The Board of Trade furthermore consented, in the recent inquiry before a Committee of the House of Lords, presided over by Lord Camperdown, to the term previous to the compulsory purchase of electric lighting undertaking, being extended, under certain conditions, from 21 years, as named in the Act of 1882, to 42 years.

It may, perhaps, be considered unfortunate, that owing to a misunderstanding on a point of minor importance, the Board of Trade later on withdrew the Bill at the third reading stage, thus sacrificing the labours of the lengthened inquiry before the above-named Committee, and leaving the law in an admittedly defective condition. There still remain, however, several points which were made clearer by the evidence given before the Committee, and which it will be of interest to refer to briefly.

The Act of 1882, in clause 27, stated, that the terms of the compulsory purchase of the undertaking were to be upon the "Fair market value at the time of purchase." Considerable difference of opinion has existed since the passing of the Act, as to the interpretation of the words "Fair market value." The view held by many (known as the "Old metal theory") has been, that the Act contemplated the value of the instruments, plant, buildings, &c., considered as old materials, sold compulsorily, and irrespective of any idea of their further use. A few persons, however, inclined to a more liberal interpretation. One of the witnesses before the Committee, Sir Frederick Bramwell, a person of considerable experience in matters of valuation and arbitration, went into the question of the interpretation of the words "Fair market value." As his views (contrary to the "old metal value" theory) seemed to be shared largely by the Committee, it may be well here to state them briefly. He considered that the words of clause 27 of the Act, "Fair market value at the time of purchase," meant, that the undertakings were to be paid for upon the "structural value," and not upon the profits of the undertaking as "a going concern." He did not, however, consider "Fair market value" to be the value of the buildings, implements, &c., merely to be pulled up and discontinued; or (as it had been sometimes termed) their old metal value. He understood "Fair market value" to be the value, at which they could be purchased and put down at that time, less any deterioration that they might at that moment be labouring under.

Before leaving this question of the modes of valuations, it may be of interest to refer to what is known as "a going concern." One of the members of the Committee (Lord Bramwell) defined "a going concern," as one which is being carried on with a view to its continuance for the purposes of profit. Sir Frederick Bramwell also pointed out, that a very good description of this mode of valuation occurred in "The Metropolis Tolls and Bridges Act 1877"; where, for the purposes of the purchase of the several bridges by the Metropolitan Board of Works, it was stated, "In estimating the undertaking, due regard shall be had to the net annual value of the tolls payable and revenue arising in respect of the undertaking of such company, to the construction and durability and present state of such bridge, the liability of the company to maintain the same, the probabilities of future profits out of future expenditure in relation to the same, and special circumstances, if any, affecting the case."

There is another point in connection with the Electric Lighting Act of 1882 about which much misconception exists; viz. the extent to which a parallel exists between the Tramways Act and the Electric Lighting Act; and the argument in favour of a compulsory purchase, at the expiration of twenty-one years, by the local authority in the latter case, because it exists in connection with tramways.

Evidence given before the above-named committee, proves clearly, that the conditions, under which the two industries are placed by their respective Acts of Parliament, are very dissimilar.

The Tramways Act allows the compulsory purchase by the local authority, at the expiration of twenty-one years, of the rails and permanent way of the tramway; which permanent way has been laid upon ground belonging to the local authority, and practically leased to the company for a term of twenty-one years. The right of purchase does not, however, extend to anything beyond the permanent way. The local authority is not allowed under any circumstances to become the possessor of the rolling stock, horses or other tractive power, buildings, &c. Furthermore, the local authority is not allowed itself to use the permanent way, but *must* re-let the line to a contractor (who may be the original company), in order to work it. Therefore the local authority cannot enter into trade competition with any other system of locomotion.

While, as regards an electric light installation, the right of compulsory purchase extends over the entire of the buildings, apparatus, and plant of every description; the local authority possessing complete power, at their discretion, to continue, or not, the installation. If it be continued, however, it comes into direct trade competition with any other form of illuminant which may there exist.

It will thus be seen that the two cases are very dissimilar; so much so, as to present no argument for the statement, that the term preceding compulsory purchase in the electric lighting undertakings should naturally be identical with that which exists in the case of the tramway.

Before leaving the subject of the recent inquiry by the House of Lords Committee, it may be well to notice certain amendments respecting restrictions as to placing electric lines, which were introduced into the Bill, at the instance of the President of the Board of Trade, and of the Postmaster-General (both of whom were members of the Committee).

By these new clauses, either of those departments of the Government might object to, or decline to sanction the erection, over any thoroughfare, or public place, of any wire not already included within the limits of a Provisional Order. Furthermore, the objection of the Postmaster-General, on the score of interference with the wires of that Department, had no limits of any sort assigned to it; nor indeed was either department bound in any way to assign a reason for exercising its veto.

It seems hardly credible that such an arbitrary and irresponsible power should even be sought for in these Parliamentary days of Home Rule agitation, and especially by the Government advocating such principles. That interference to this extent was, however, contemplated, is proved by the admissions made by the two above-named Government officials themselves. Viz. that a person having a house to be lighted by electricity, on one side of a street, and having placed the generating plant in another building also belonging to him, but on the other side of the street, could not connect the two buildings by a wire passing overhead (no matter what other permission he had previously obtained) without the special sanction of each of the above Government Departments; a sanction which might be granted, or withheld, at will, and without any reason being given for such action.

With clauses in it of such an arbitrary character, it is hardly to be regretted that the Electric Lighting Act Amendment Bill 1886 was withdrawn by the Board of Trade. Indeed it behoves all municipal authorities, as well as the general public, to prevent the repetition of a partially successful attempt to introduce such arbitrary clauses into public legislation.

The extent to which central station lighting in towns already exists out of England, may be perceived from the following figures placed before the Committee. On the Continent of Europe about thirty stations exist, with about 50,000 incandescent lamps in connection therewith; while in the United States of America about fifty stations are in operation, embracing about 50,000 arc, and 150,000 incandescent lights. In England there are no proper centres of public distribution. Attempts have been partially made at Colchester, Brighton, Eastbourne, and Hastings. But installations, private ones it is true, which more nearly represent the principle of central station distribution, are such as exist at the Grosvenor Gallery, and at the Paddington Station of the Great Western Railway, both in London, at the Tilbury Docks, near Gravesend, and at the Forth Bridge Works in Scotland.

In the supply of large towns, a considerable number of these distributing stations, varying of course with the size of the town, will be required. It is probable that these distributing stations will themselves be supplied by electricity from a generating station, situate outside the limits of the town; whence a current will be conveyed to the several stations (for reasons of economy in the conductors, &c.), at a much higher pressure than that which would exist, or is legally permissible, between the distributing stations and the houses. The outside generating stations would be analogous to the impounding reservoirs of a gravitation water-supply to a town, while the distributing stations would act as service reservoirs. The instruments, with which (at present) the conversion of the high-pressure current to the low-pressure one is effected, would be by means of secondary or storage batteries, or else by secondary generators, or transformers, as they are sometimes called. Several forms of each class exist, and many improvements in their manufacture have taken place within the last few years.

Also more than one useful kind of electric meter is in actual operation.

Still it is not probable, that much practical information can be gained in the matter of central station lighting by electricity, till a number of these stations have been laid down, and have been in operation for some time; and this the present state of the law almost forbids.

DISCUSSION.

Mr. Douglas C. Bate, A.S.T.E. & E.: Mr. Shoolbred has so curtailed his paper that I fear we have lost the best and most interesting part of it, at least for this afternoon. First, as regards the Board of Trade rules, the twenty-one years' limit has proved a complete failure, and utterly stifled electric lighting on any extensive scale. Chelsea is about the only place where, at the present moment, a provisional order is expected to be worked. In the United States of America, on the contrary, where prohibitory laws are not in force, electric lighting has made very rapid strides. The statistics of the progress of the system which I represent (the Thomson-Houston) show that in October, 1883, there were twenty-two local companies operating, in as many cities, a little over sixteen hundred arc lamps, whilst on January 1st of this year, the total had risen to 106 companies, operating over 13,000 lamps.* This does not take into account private and isolated installations, of which there are quite a large number, but is solely confined to city lighting. Although the late Parliament failed to do anything to ameliorate the onerous condition of the law, I trust that both in the interests of the electric lighting industry and also in those of the public at large, the next may see their way to relax the stringency of the Act, and give us a limit of forty-two years or more in which to recoup the great outlay necessarily attendant on lighting on a large scale. Amongst other things which, personally, I believe may be expected to receive attention, is the present limit of electromotive force or potential allowed for domestic lighting. As an eminent electrician and engineer, Mr. W. H. Preece, of the Post Office, has remarked, "It is singular that no fatal or even severe accident has ever happened anywhere to one of the public through the use of high potential, and even as regards those employed in the installation and maintenance of electric plant, they stand in greater danger of injury from the force of gravity by falls from ladders and buildings than they do from the electricity itself." Now, referring to the marvellous success of the Thomson-Houston system, which has not only fought and overcome gas and other interests, but in many of the places lighted has actually ousted other systems of electric lighting, perhaps the primary reason has been one, the validity of which I am perfectly contented to leave to the judgment of those Members of your Association who have seen our lamps burning in Hanley, with a steadiness which, I believe, is unequalled by any other arc lamps in the world. Another cause of success is the economy of working, for be it remembered that, to sustain a Thomson-Houston lamp of 1200 candle-power, requires a bare half horse-power. This statement is fully borne out by the report of Dr. Arrhenius, the famous Stockholm expert, who in his report on our installation at Hernosand, the first electrically lighted town in Europe, states that our lamps gave 1400 candles for less than five-tenths of a horse-power. Again, the carbons in use cost less than three-halfpence per foot, whilst on other systems fourpence to sixpence is by no means an unusual price. The main stay of the whole system is, however, the automatic regulator, which permits over 50 per cent. of the lights to be suddenly switched off without change or flicker in the remainder, and owing to which we are quite independent of steadiness of motive power, be it steam, water, or even a gas engine. On several occasions we have erected temporary installations, and run the lights successfully with variations in speed of upwards of 50 per cent. You are most of you doubtless aware that the Thomson-Houston system received the only gold medal for arc lighting at last year's Inventions Exhibition, and there, in the presence of the jury, upwards of 20 out of 45 lamps running on one machine—in fact, the whole of those lighting the China Court—were suddenly extinguished without in the slightest degree affecting the remainder; and this result was obtained without the introduction of resistances or other wasteful methods of compensation, but simply by the action of the automatic regulator, and with a proportionate saving in power consumed. The simplicity of every part of the machinery, which not only reduces wear and tear to a minimum, but also enables the parts to be shifted and renewed in the shortest possible time, is also a great feature of this system; and as an instance of this I may mention the fact that when on one occasion, at the Inventions Exhibition, the bursting of a steam pipe completely wrecked the commutator of our 45-light dynamo, the injured part was taken off, a new one fitted, and the lights again running inside of half an hour, a result which I challenge any one to accomplish with any machine in the world but a Thomson-Houston. I might pursue this subject further, but time does not permit of my doing so, and I consequently leave the present installation to speak for itself, simply asking if you ever before saw arc lamps running so well, and this off a steam roller. One word more and I have done. There seems to be an impression that arcs are all very well for street lighting, but unsuitable for shops; to this I can only say that at Taunton the bulk of our lights are in shops, and great satisfaction they are giving. What is thought of them can be seen by extracts from a Taunton paper; whilst at Edinburgh Exhibition, where Thomson-Houston lights are employed, they are doing well enough to be spoken of by the *Times* and the *Electrical Engineer* in flattering terms.

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* This immense extension still continues the figures up to July 1st, 1886, showing that there are now 133 companies operating 16,910 lamps.

The President: Some of you may have seen the lights here flicker a little, and some of you may not. It is owing, when it does happen, to the difficulty of placing the steam roller with the belt exactly the same length every night. Mr. Bate mentions the private lights in shops at Taunton as being satisfactory there. I may say there is a shop here where several arc lights have been used during the winter, but they are not to be seen now during summer-time except on Saturday nights. Did I understand Mr. Bate to say that if a dozen lights in a series were switched out, there was no diminution of power?

Mr. Bate: When a number of lights are turned off, although the speed of the machine remains the same, the power consumed is reduced in proportion.

The President: There is one point I do not think Mr. Bate made quite clear, that, when a number of lights were switched out, there would be no alteration in the speed of the dynamo, but there is a saving in the steam used. The amount of steam required, therefore, is in proportion to the number of lights in existence. With other systems, I believe I am correct in saying that, where two or three lights are switched out, they must put in resistance to overcome that. Then, of course, the steam is not saved, but has to be expended just the same as if the lamps were burning. I have great pleasure in moving a vote of thanks to Mr.

Shoolbred for his paper, and to Mr. Bate for the address he has delivered.

Mr. W. H. White: I have great pleasure in seconding the vote of thanks to Mr. Shoolbred and Mr. Bate. I am only sorry that so few of us are electricians, and are therefore unable to discuss the paper read to us to-day as it should be discussed. As we are to have Mr. Shoolbred's paper printed in full in our 'Transactions,' we shall be able to study it at our leisure, and I have no doubt we shall learn a great deal from it. Perhaps on some future occasion Mr. Shoolbred will favour us with another paper on the subject, when we may be better able to discuss it than we are at the present time.

Mr. Shoolbred: I must remark that the Thomson-Houston is not, as has been stated, the only system where lights can be switched out without causing flickering of the others. There are many other installations, burning in parallel, that I know of, where there is not the slightest necessity to introduce resistance; and where at least 80 per cent. of the lights may be turned out without the engineman knowing anything about it. This has been regularly done for the past three years, with Siemens and with Crompton dynamos. In the large installations I have had under my direction at the Forth Bridge, it is not known at the engine-room whether they are burning arc or incandescent lights, or whether two or three lights or several dozen. There is never the slightest alteration made, nor any extra resistance added by hand; the arrangements are entirely automatic. Even in the arc lights working in series, from machines of the above makers, and working precisely as are the Thomson-Houston machines, the alteration in the number of arc lights actually burning (an operation which is constantly taking place), never causes any perceptible effect upon the remaining lights. There are likewise numerous other installations throughout the country, take for instance the Exhibitions at South Kensington and at Liverpool, where similar facilities exist, for alteration at will in the number and character of the lights.

Mr. Bate: Mr. Shoolbred has drawn attention to the fact that other systems of electric lighting admit of lights being turned off without detriment to the remainder. I fancy therefore that he has slightly misunderstood me, and believes I claim the monopoly of this feature. I do not. I, however, do claim that the Thomson-Houston is the only system of series arc lighting which is perfectly and automatically self-regulating under the most sudden and extensive changes of speed and load. Incandescent lamps can, of course, be turned out with impunity on the parallel or multiple arc system, such as they are usually erected on. Arc lamps installed on the same lines can also be switched on or off with pretty good success, and if it is a question of lighting a moderate sized works or building, arcs in parallel may be quite suitable, but if the problem is to maintain the whole lighting of a town from one centre with probably some hundreds of lamps in streets and shops, then I strongly maintain that series lighting and series lighting alone is suitable. Before you can successfully carry on electric lighting on a large scale you have the capitalist and the consumer to satisfy. The first will ask you what is to be the outlay? and other things being equal will choose that plan on which the smallest annual charge for interest and depreciation must be laid, and right here the cost of conductors will come in, and throw parallel lighting out of court. Take a single straightforward example: you have forty 1200 candle-power lamps to maintain at approximately equal distances along a straight mile of road, the current taken by each lamp is 6 amperes. If, then, you put them in series you must have a conductor which shall be capable of carrying 6 amperes of current, and a number 10 B.W.G. copper wire is found to be sufficient; this wire will weigh about 290 lbs. per mile, approximately $\frac{1}{8}$ ton, or $\frac{1}{4}$ ton for the lead and return of your ideal circuit. But try what you can do on the parallel system: as far as the first lamp the current is now 40 times 6 amperes, and diminishes by 6 as each lamp is passed, the conductor must therefore be capable of carrying 240 amperes as far as No. 1, 234 to No. 2, and so on in gradually decreasing progression; and if I am not mistaken, you will soon find you must expend 20 times the weight of copper, that is to say, your conductor will weigh not $\frac{1}{4}$ ton but 5 tons. Imagine you have not 40 but 400 such lamps to run. Multiply your figures by ten, and you will find that they read for series lighting $2\frac{1}{2}$ tons, for parallel 50. What will your capitalist say to that? Now let us look at the question from the consumer's point of view. If you have to pay interest on capital expended on 50 tons of copper conductor instead of on $2\frac{1}{2}$ tons, then you must charge more for the lights, and the worst I can wish any one is that they should get the lighting of a whole town, wire it on the parallel system and get fully started, when I will step in and run anybodies' arc lights on the series plan, and sell light for 50 per cent. less than the parallel man can do without dead loss. Mr. Shoolbred also remarks that it is ludicrous to call a Thomson-Houston dynamo a system; that is just what I say; but I do call dynamo, automatic regulator, wall controller, and lamps combined, in fact, the whole apparatus complete a *system*, and, what is more, the best and cheapest system in existence, and confidently challenge the world to produce its equal.

On Thursday the Members dined together at the North Stafford Hotel: among the visitors were W. Woodall, Esq., M.P. for Hanley, Surveyor-General of Ordnance and Chairman of the Municipal Corporations Association; the Mayors of Hanley and Stoke-on-Trent, and the Chairmen of the Joint Hospital Board and Works Committee.

On Friday afternoon the Members visited the Bucknall Road Canal Bridge, and observed the marks of periodical subsidence and the means taken for raising the bridge from time to time; the Hospital for Contagious Diseases, at Bucknall, designed by G. W. Bradford, the architect to the Hanley, Stoke and Fenton Joint Hospital Board; the Hanley Sewage Works (for description of which, see Vol. VII. of the 'Proceedings'); the Quarter Sessions Court and approaches in course of construction.

The Members also visited Mr. Ridgway's Flour Mills, where the most modern system of machinery is adopted, the mills being brilliantly lighted throughout by electric incandescent lights.

On Saturday visits were paid to the premises being altered for a Free Library, the Baths in Lichfield Street, the new public Slaughter-houses in course of erection in the Cattle Market, Messrs. Hampton's Marl Works, where an interesting specimen of Sigillaria was seen exposed to view in situ; Joiner's Square and Nelson Place bridges. The following manufactories were also visited during the day: Messrs. Buller & Co., Messrs. Taylor and Tunnicliff's, and Messrs. Woolliscroft and Sons.

Visits were made to inspect the temporary and experimental installation of the Electric Light. On Saturday night twelve arc lights were placed in the principal market, and four in the Market Square; on other nights all were placed in the central squares in the town. The steam roller providing the necessary power, and Messrs. Laing, Wharton and Down providing the dynamo and plant on the Thomson-Houston system of arc lighting.

APPENDIX.

VOLUNTARY EXAMINATIONS.

SYLLABUS.

The Association of Municipal and Sanitary Engineers and Surveyors have undertaken the holding of Voluntary Pass Examinations for Candidates for Surveyorships under Municipal Corporations and the Local Government Acts.

There will be two Examinations in each year, one in April, in London, and one in October, in some provincial town to be fixed on by the Council, and advertised in the "Builder" six months beforehand.

The next Examination will be held in Liverpool, in October 1886, of which due notice will be given in the "Builder" of the time and particulars.

The Examinations will be by written papers, and *viva voce* upon the four following subjects :—

1st. Engineering as applied to Municipal work.
2nd. Building Construction and Materials.
3rd. Sanitary Science as applied to Towns and Buildings.
4th. Public Health Acts, and Rivers Pollution Acts.

Examples of the class of questions proposed to be asked under these heads are appended hereto.

Candidates will be allowed two hours to answer the questions under each of the four heads, and will not be required to answer more than four questions on each subject. The *viva voce* examination will be held after the written papers have all been sent in, and will be directed to the further elucidation of the answers to the papers on each subject, and to such practical points as fairly arise therefrom.

The Examinations will extend over one or two days, as circumstances may require, and in the latter case the arrangements will be as follows:—

First day	..	10 to 12	..	Engineering.
,,	..	2 ,, 4	..	Building Construction.
,,	..	6 ,, 8	..	Sanitary Science.
Second day	..	10 ,, 12	..	Public Health Law.
,,	..	2 ,, 5	..	*Viva voce* Examination.

The total number of marks required to constitute a pass will be 50 per cent. in each of the subjects, except Public Health Law, in which 30 per cent. only will be required.

Each candidate has to fill a Form of Application, to be obtained from the Secretary.

The fee for each Examination will be 3*l.* 3*s.*, one guinea to be paid on application, and the balance on the day of examination. Should the candidate fail, he will be entitled to present himself again at the next, or any subsequent Examination, on payment of one-half of the above fee.

No further charge will be made to the candidate than the fees above mentioned.

Candidates that do not present themselves for the Examination forfeit the entrance fee.

Successful candidates will be entitled to receive a Certificate in the form of a "Testamur," signed by the Examiners for the time being, and countersigned by the President and Secretary of the Association in Council.

Further details and particulars may be obtained on application to Mr. Thos. Cole, Secretary to the Association, 6, Westminster Chambers, Victoria Street, S.W.

SUBJECTS OF EXAMINATION.

I.—Engineering as applied to Municipal Work:

A. Land Surveying and Levelling.
B. Hydraulics.
C. Drainage and Sewerage.
D. Water Supply.
E. Road Making.

II.—Building Construction: Strength of Materials:

A. Materials.
B. The Construction of Public and Private Buildings.
C. Building Bye-laws.

III.—Sanitary Science as applied to Towns and Buildings:

A. Ventilation.
B. Sewage Disposal.
C. House Drainage.

IV.—Public Health Acts.
Rivers Pollution Acts.

EXAMPLES OF QUESTIONS.

The following are the Examination Papers set to the candidates at the First Examination held in London, April 1886, and serve as examples of questions proposed under the different sections.

Subject:—Engineering as Applied to Municipal Work.

Examiner.—Clement Dunscombe, M.A., M.Inst.C.E., City Engineer, Liverpool.

1. Describe the chains used in Surveying, why they are of the prescribed lengths, the mode of measuring with them, and the precautions requisite to ensure correct results.
2. Define Land Surveying, and describe briefly the method of conducting a survey with the chain only or by combining it with angular instruments. Describe the instruments used; and give a form of field-book filled in with a few imaginary readings.
3. State the different instruments used in levelling, and the class of operations to which each method of levelling is suitable.
4. Explain by a diagram the difference between the true and apparent level, and prove that, approximately, the correction for curvature in feet = two-thirds of the square of the distance in miles; the mean diameter of the earth being 7916 miles: what further correction is requisite and how are both obviated in practice.
5. What is the "Torricellian" theorem? Explain what is meant by "Coefficient of Contraction"? "Charge" or "head"? "Hydraulic mean depth"?
6. Show that for pipes running full, or half full, the Hydraulic mean depth = one-fourth of the diameter. Give a formula for the theoretic discharge per second, through an orifice in a thin plate.
7. Calculate the velocity in feet per minute, and the discharge in gallons in twenty-four hours, of a pipe two feet in diameter with an inclination of 1 in 704 when running full.
8. Briefly describe how you would proceed to sewer a small town, assuming your own data as regards its area, population, rainfall, and water supply; the outfall being into a brook some distance from the town.
9. What precautions would you take to render the sewers self-cleansing, and describe how you would provide for exceptional rainfalls. Draw a sketch of an egg-shaped sewer 3 feet × 2 feet, and state the advantage it possesses over a circular sewer.
10. Draw a sketch of the plan and section of a manhole, and also of an Inspection Shaft, and state how you would provide in the manhole a simple means for periodical flushing.

11. What are the most important data to be obtained respecting the rainfall for the purposes of water supply?
12. Describe briefly the different means employed to supply towns with water.
13. State the advantages of a "Constant Service." What precautions should be taken to prevent waste?
14. Draw a cross section of an ordinary country Road, 40 feet in width, including two 6-feet footpaths, which will be finished in gravel. Mark thereon the cross section of the carriage-way and inclination of the footpaths and the depth of sub-foundation, road metal, drainage, &c., you would recommend.
15. Describe how you would pave a street, subject to very heavy traffic, the foundation you would adopt, the quality and size of sets, curbs and channels you would use; the footpaths being finished in 3-inch flags. Specify briefly for the various materials.

SUBJECT:—BUILDING CONSTRUCTION, &C.

Examiner.—W. Geo. Laws, M.Inst.C.E., City Engineer, Newcastle-on-Tyne.

1. What is meant by "bond" in Masonry and Brickwork? Give sketches of "English" and "Flemish" bond for a 14-inch brick wall, also for a 9-inch wall.

   In what cases is Flemish bond not applicable, and why?
2. What are the proportions of ordinary lime mortar? How would you specify the mortar for first-class work? Give a ready test of the fitness of sand for making mortar.
3. What are the chief properties of Portland Cement? With what materials is it used in Concrete, and in what proportions? Describe the process of putting in a Concrete Foundation.
4. In what mode is Concrete used in constructing Fire-proof Floors? Give sketches of an approved design.
5. Give a sketch of an ordinary Kingpost Roof Couple, name the various members, and show by arrows the directions of the strains. Show the positions of the "Purlins," "Rafters," and "Slate Laths."
6. Write a short Specification for the walls and roof of an ordinary Brick Dwelling House.
7. What is the usual pitch for a staircase, and the relative proportions of the "tread" and "riser"? Give TREDGOLD'S rule for their sizes, or any other you know.
8. What is a safe load, per square foot, to put on sound "Brick in Cement," say in a Factory Chimney?
9. A Redwood Joist, 9 inches by 3 inches, has bearings 12 feet apart, what distributed load will it break under? (Coefficient of rupture for Red Pine, 13 cwt.)
10. In combining Brick and Stone, what precautions would you use in the following cases, and why?
    - 1st. Setting a Window Sill.
    - 2nd. In building a Brick Wall with Ashlar four-course quoins.
11. What are the requirements of the "Model Bye-Laws" as to open space behind Domestic Buildings?

SUBJECT :—SANITARY SCIENCE.

Examiner.—R. Vawser, M.Inst.C.E., Manchester.

1. Sketch a detached dwelling house, with three entertaining rooms on ground floor, and select the situation for Scullery, Butler's Pantry, Lavatory and W.C. on ground floor; W.C., Bath and Housemaid's Closet on first and second floors; and Laundry, &c., in basement: and show the best way of draining same into a sewer 60 feet from the house, the invert of the sewer being 17 feet below ground floor and 4 feet below basement.
2. Sketch a pair of semi-detached houses, with two entertaining rooms and scullery on ground floor, Wash-house in basement, and Bath and W.C. on first floor, and show the best way of draining same into a sewer 25 feet from house and 15 feet below ground-floor level.

'The candidate is not expected to design the houses, but must localize the apartments to be drained, and must fully describe by sketches and otherwise every essential particular in regard to the drainage thereof: the candidate should assume his sketch will be handed to a draughtsman with no special experience in sanitary work, and who will have to make complete drawings and specifications without other instructions than the sketch affords. The mode of ventilating the drains and soil pipes, and the means for preventing sewer gas entering the house must be fully illustrated, as also every sanitary requirement in connection with the Closets, Baths, &c., within the house: the size of every pipe and drain, and the approximate gradient of the drains should be given.

3. What are the requirements with respect to a drain within or under a dwelling?
4. Describe the most suitable Closet for rows of Cottages within an urban district where 150 square feet of yard space is allowed, and where Water Closets are impracticable. Describe also the requirements as to the ventilation and situation of such Closet with regard to neighbouring Dwellings and Workshops, and as to the removal of the soil therefrom.
5. Describe in the same manner the best Closet for detached Cottages in rural districts.
6. Describe the best arrangement for storing ashes, garbage, and solid household refuse upon the premises preparatory to its removal by scavengers' carts upon the assumption that 150 square feet of yard space is provided to each house, and give your views as to the removal and ultimate disposal of this refuse.
7. Assume that in an urban district a local preference exists for Water Closets to Cottage Dwellings, state reasons for or against their adoption: If you prefer another form of Closet, state the particulars and reasons for your preference, and the conditions to be observed in the construction and management of Water Closets if they are imperative; and what precautions are necessary to prevent the saturation of subsoil by Closets and drains.
8. Describe how branch drains should be constructed and connected with the main sewer so as to prevent deposits and gases therein: and how the escape of sewer gas into Cottage Dwellings and back yards can be prevented, and what description and extent of drain ventilation (if any)

you recommend (distinct from the ventilation of main sewers) for Cottage branch drains; give your views as to the flushing and disinfection of branch drains, and state how it can be most efficiently and economically accomplished.

SEWAGE DISPOSAL.

9. Under what circumstances would sewage purification by Irrigation be preferable to any other method?
10. State briefly the ruling difference between Irrigation and Filtration, and the purifying capacity of each: and under what circumstances Filtration is preferable to a chemical process.
11. Is it desirable to treat crude sewage before purifying it by Irrigation or Filtration? If so, state why, and describe how it should be treated.
12. Suppose the sewage of 20,000 inhabitants must be purified on 6 acres of land, give a general detailed description of the necessary works (assuming your own conditions), and give a general description of the works, their capacity and construction, together with details of the process of purification, the disposal of the sludge, and the treatment of the effluent.

SUBJECT:—PUBLIC HEALTH ACTS, &c.

Examiner.—E. B. Ellice-Clark, M.Inst.C.E., Hove.

1. What are leading Sections in the Public Health Act of which a local Surveyor should have special knowledge? *

   State them under their various heads:—

   Sewerage and Drainage.
   Scavenging and Cleansing.
   Water Supply.
   Highways and Streets.

2. How would you apportion the cost of Paving, &c., a Private Street under the 150th Sec. of the Act—in a case where it was necessary to (*a*) provide a new sewer with manholes, gullies, &c.; (*b*) re-form and re-metal the entire roadway; (*c*) put in new channel; (*d*) reset the existing curb and (*e*) provide new paving for footways opposite one property and (*f*) reset paving for footways opposite the remainder; and (*g*) provide the means of lighting?

   State in detail on what principle you would apportion the respective costs of these works, and

   State who are exempted from the costs incurred under the 150th Sec. Public Health Act.
3. What provision is made in the Public Health Act so as to regulate the line of Buildings in new Streets?
4. What is deemed to be a new building?

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* The numbers of the Sections need not of a necessity be given—a general description of the powers under such Sections will be sufficient.

BOARD OF EXAMINERS.

R. Vawser, M. Inst. C.E., Manchester (Past President).

Lewis Angell, M. Inst. C.E., F.R.I.B.A., Engineer to the Local Board, West Ham (Past President). One of the Examiners under the Metropolitan Building Act.

H. P. Boulnois, M. Inst. C.E., Borough Engineer, Portsmouth (Member of Council).

G. F. Deacon, M. Inst. C.E., Water Engineer, Liverpool (Past President).

C. Dunscombe, M.A., M. Inst. C.E., City Engineer, Liverpool (Vice-President).

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C. Jones, Assoc. Inst. C.E., Surveyor to the Local Board, Ealing, W. (Past President).

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E. Pritchard, M. Inst. C.E., 37, Waterloo Street, Birmingham (Past President).

W. H. White, M. Inst. C.E., Engineer to the Local Board, Oxford (Past President).

FORM OF APPLICATION.

No. , ______________ 188 .

ASSOCIATION OF MUNICIPAL AND SANITARY ENGINEERS AND SURVEYORS.

Voluntary Examination for Candidates for Surveyorships under Municipal Corporations and the Local Government Act.

Name and titles in full. I, ______________________________

of ______________________________

having paid the required entrance fee of One Guinea, and intending to become a candidate for the office of Municipal Surveyor, do hereby apply to be examined as to my competency to perform the duties of such office, and the following is a correct statement of the particulars required of me, that is to say:—

Candidate must here state:—

His age. ______________________________

Under whom articled or served. ______________________________

His past engagements, if any, and present occupation. ______________________________

The places where and when, or under whom he received his professional education. ______________________________
____
____

Signature of Candidate ______________________________

The examinations are held in April and October. This form, together with the entrance fee of One Guinea, must be sent in to the Secretary on or before the 5th March or the 5th September respectively.

THOMAS COLE, *Secretary.*
6, Westminster Chambers, S.W.

THE CERTIFICATE.

ASSOCIATION OF MUNICIPAL AND SANITARY ENGINEERS AND SURVEYORS.

WESTMINSTER,

________________ 188 .

THIS is to certify that at an examination held by us on the________ and________days of________188 , Mr.________________was carefully and deliberately examined on the subjects necessary to qualify him for the office of a Municipal Engineer and Surveyor, and that he satisfied the Examiners, who have hereunto appended their names.

____
____
________________________ } *Examiners.*
____

Reported to and confirmed by a Meeting of the Council of the Association held in London on the________ day of________188 .

________________________*President.*

________________________*Secretary.*

THE SANITATION OF LONDON AND THE SUBURBS.

By EDWIN CHADWICK, C.B.

I purpose to give, as nearly as my information enables me to do, a general outline view of the comparative sanitary condition of a good suburban residence as compared with that of an urban residence. If suburban villas be well drained and be in good sanitary condition the death-rate ought to be about 10 per 1000. I have estimated that if a middle-aged man who spends, say, a sixth of his working time in going to a place, say in Westminster, or in some parts of the City, and remains there in business some six hours and then returns to live during the rest of the day and to sleep in the purer suburban air, he will gain upwards of a fourth more of life. The relative vitalising power of a pure suburban air, as compared with an ordinary urban air, such as that which pervades the Government Offices at Whitehall and all the houses thereabouts, would be displayed in the case of the occurrence there of a very serious accident. Skilful surgeons would be aware that the chances of recovery would be largely improved by the removal of the case to the purer suburban air. If the case is one which cannot be removed they will then wash with antiseptic solutions and spray the air of the room where the operation is to be performed. Mr. Lister is careful and successful in doing this where it is necessary to perform this operation. But all this superiority of the residence in the pure air of the best suburb depends largely on the good sanitary condition of the suburban dwelling. If the house drains be too large and badly laid, if the water is not properly applied, if there be stagnant and putrid deposit within the house, or if the house, though well drained, be connected without proper trap with a sewer of deposit instead of a self-cleansing sewer, then it will be fermented by the lethal gases, and though it may be mitigated by the open air of the outside, the health of the resident will be deteriorated. I find from the Registrar-General's returns, for an average of three years, that the mean death-rate of this suburban district of Putney is 15 per 1000. This is an advance by one-fourth upon the general death-rate of the Metropolis; but I believe that it may be advanced to an average of one-half by complete sanitation. The gains and losses of life are, however, differently apportioned to the different classes of society. Thus I find that the mean age of death of all born men, women, and children of the gentry and professional classes is 50·5 years, and of the shopkeepers it is 27·6, whilst of the wage classes it is only 23·9, or less than the urban general average; whilst of the children of the villa residents, thirteen die under five years of age; of the shopkeepers thirty-eight die, and of the wage classes forty-eight die. Nearly half of their children are in their graves before their fifth year. The returns which I have obtained display the relative prevalence of death from the principal zymotic diseases which we designate the "filth diseases," whilst of the villa residents, 7·55 die of them, of the shopkeepers 17·93 die, and of the wage classes 20 fall by them. And whilst of the villa residents 3·77 attain old age, of the tradesmen 2·76 ditto, but of the wage classes only 1·48. The examination of the sanitary condition of the houses of the wage classes and of the shopkeepers has yet to be made, but an Association had, with its sanitary inspection, made examinations which display the most potent causes of the losses of life of their children and of themselves. I believe, from having had formerly occasion to pay attention to them, that suburban districts where the death-rates are yet below the urban districts of the Metropolis, are all in a similar condition to Putney or Kingston, where the death-rate is 15 in a thousand, Richmond, where it is now 17, and Wandsworth, where it is 18, or below the general death-rates of the urban districts. And this will be so with new dwellings, even with first-class dwellings, where securities are not taken against the common defaults of architects. Some time ago, when I was living at Richmond, I found the general death-rate was twenty-four in a thousand, or as high as in London. I remonstrated with the Superintendent Registrar that this was so, when he accounted for it by the fact that there were continued additions of new blocks of buildings, and that every additional new block, instead of effecting a reduction, created an addition to the death-rate. That was chiefly due to the occupation of newly-built houses before they were dry; of houses in which the sanitary requirements were, as is common, neglected, or unskilfully executed. Within a month after the occupation of the new houses it was a common occurrence to see the carriage of the physician at the door.

In such new villa residences, as in many of the old ones, there are here many of the rental of from 30*l.* to 600*l.* a year. Of the large houses in Wimbledon, one occupied by an engineer of Great George-street was found to have been occupied by him in this condition: the main house drain went under the building, the connection of the drain had not been made, and there was a deep mass of putrid deposit between the ground and the flooring; there was a spring in the garden constantly running under the floor, liquefying the deposit, which had to be periodically pumped out. The occupier must have slept, and breathed an air charged with the emanations of putridity in the basements, and must have been living in a condition of the worst urban air, and have lost all the advantages of the transit. It cost a subsequent tenant between 300*l.* and 400*l.* to put things right. This is one example of many other well-conditioned houses on the Wimbledon suburban resort. Of 16 detached villa residences, letting from 30*l.* to 600*l.*, every one was found here to be in a faulty condition. Some of them were demonstrated to the aggrieved owners to be in a most dangerous condition, and some afterwards demonstrated by improved health on amendment. Such is the condition of better class houses, but the lower class houses in this as well as in other suburban districts are proved by the amount of disease to be worse. Inspection of this class of houses is generally opposed by the owner on the score of expense. And it is proper to state that if he undertake the charge of repairs himself it will generally be at a threefold expense, and will then not be done responsibly or effectively. But if it be done under a common contract it may be done at one-third of the expense, and charged in the shape of an improvement rate on the party benefited, usually at about threepence-halfpenny per week. This would effect an important reduction of the insurance charges entailed by excessive sickness and premature mortality, which would extend generally along the line of metropolitan suburban residences. Our American brethren are bestirring themselves with effect in sanitation in some instances. The Board of Health of Illinois, I find by a report sent to me, have set a good precedent by an enactment that every house within their district shall undergo an examination by their sanitary inspectors. House-to-house amendment, with self-cleansing sewers, would effect the primary amendment required, for the purification of the river, and for the general system of the sewerage of the Metropolis, the production and the discharge of sewage that is fresh instead of sewage that is putrid. By culpable ignorance this preparation has been altogether neglected, and it has been assumed that the only condition of sewage that could be dealt with was sewage in its present condition of putridity. Hence the violent opposition to the vicinity of proposed sewage farms. If the opponents had seen the sewage farm at Croydon or other places where the separate system with self-cleansing house drains and self-cleansing sewers has been carried out, they would have found the process to be an important improvement upon the ordinary agriculture, with top dressings of the solid manures, and the removal of all reasonable grounds of opposition.

I will now advert to the subject of water supply. In this and other suburban districts the water supply has been on the old intermittent system, into large butts and cisterns, in which the water stagnates, and in which good supplies are commonly made bad, and bad supplies are made worse. The intake for the supply of this district, and the intakes of other districts, is from river sources, very much improved, certainly, from the reduction of the putrid sewage from houses, but still subjected to the sewage from the surface washings of land heavily manured by the putrid solid manures of towns or from the market gardens. It has been proved that more than three-fifths of the water pumped in is pumped in to injurious waste, and to the ultimate deterioration of the sewage. On a public footing, as at Manchester and other places, this excessive waste (I have the authority of the Messrs. Quick, the well-known engineers, on their experiments at Amsterdam), is redeemable by fully one-half. This reduction of the waste by one-half or by three-fifths would nearly dispense with all the intakes from the river sources, and leave but little to be added from spring or other sources. Under unity of administration I believe that a finer supply of water may be obtained for the Metropolis than for any metropolis in the world. In my time we found that double the actual consumption could be obtained by subsoil drainage, from the then unoccupied and unharmed Surrey sands. It would be a subject to be pressed for examination how they are occupied now. Supplies from such sources so obtained are of the highest order of purity, softer and purer than the ordinary rain water, and needing no second filtration. But the process of softening the chalk spring water has been so far improved, that the hard Thames water, of sixteen or eighteen degrees of hardness, may, at an inconsiderable expense, be brought down to four degrees, or even three degrees of hardness, or to that of the distilled and aerated water, as experienced, as I am informed, at Canterbury, at Bushy, and at an increasing number of places. Let ladies think of washing, not with hard water, which often gives "nutmeg-grater" skins; of saving, by a third in tea, and tea of an improved flavour; and of the saving in culinary operations; and in soap in clothes washing. But these results can only be obtained under unity. It is now proved that the Government were largely misled, and have subjected the ratepayers to some three millions of loss by the rejection of the bargain proposed by Mr. Edmund James Smith. In addition to an accruing loss of one hundred thousand pounds per annum by the continued neglect of his plan there is the great gain by dispensing with all the establishments now engaged in the collection and distribution of water from the river sources—that is, of half of the existing establishments. There is one principle of sanitation to be mentioned in connection with the process of water collection, and that is the relief of supersaturated land, by subsoil land drainage. Richmond Park was moderately well drained, with the result of an important reduction of the fogs prevalent there; and also with a valuable improvement in the health of the deer and the cattle maintained there. An examination would be required to ascertain what improvement might be effected by the drainage of the bye-ways, and through occupied lands, and by the drainage of the commons and the unoccupied lands. Measures were provided for the general subsoil drainage of all the lands between low-water mark in the Metropolis and of the suburban marshes, by which a considerable relief from fogs and an improvement in the public health would be effected.

I stay to state the extent to which the improvement of the health in this as well as in other suburban districts of the outer ring of the Metropolis may be accomplished. By them the promise of relief from the suburban residence of a reduction of the death-rate by one-third would be fully accomplished. To one acquainted with the extent of the preventible diseases and of the tried and proved means of prevention, there will be no doubt whatsoever of that being capable of accomplishment; and that of the six hundred deaths which took place within the average of the last three years, two hundred might have been saved, and with each case of death, at least twenty cases of sickness and of working disability. I bear in mind that in these suburban districts valuable improvements have been effected, and yet the death-rates remain at 15, 16, and 17 per 1000. I have received instances where by more complete measures the death-rates have been reduced from similar conditions to 11, 10, and in a number of instances to eight in a thousand, as at Malvern. I had an important example of sanitary treatment in the United States on the separate system, at the town of Pulman, consisting of a manufacturing population, where the death-rate was eight in a thousand in 1882; but I have recently received a report that the death-rate for the last year was 6¾ per 1000, or not above one-fourth of the death-rates in New York, or in Manchester or Preston. I have a confident belief that by complete measures of sanitation in these suburbs, the death-rate is reducible to eight in 1000 with a corresponding augmentation of the "life-rate," as we shall call it, of the mean duration of life, in which all may participate, and place these suburbs on a level with the majority of distant "health resorts." In the greater London, by the abolition of cellar dwellings, by the clearance of slums, by the widening of streets, and by the scattered work of our sanitary inspectors, the death-rate has been reduced to less than one-half what it was in London in the time of Elizabeth. Nevertheless, we know that there is yet an excess of twenty thousand preventible deaths, and of twenty times that number of preventible cases of sickness, and of working disability in the Metropolis annually—the results, now chiefly of vestralisation. To this element must be attached the increasing number of serious fires, for the prevention of which it has been proposed that all the streets and roads, including those near suburban dwellings, should be hydrated, with apparatus kept always ready for constant use for street washing and road watering; that all the police should have keys of the hydrants, with the hose, and be enabled to bring the water to bear within three minutes upon any fire. For the protection of life and property to be effectual it was the rule of the late Mr. Braidwood to try to be on the spot within five minutes. Beyond that time, as a rule, large fire engines were only to prevent the extension of fires to other premises. It is too long to give a history of this service and the exemplification of the principle that small things near are more efficacious than big things at a distance, and how it was adopted first at Liverpool, then at Manchester and at Glasgow, with the general result of a reduction by two-thirds of the rate of fires still prevalent in the Metropolis, where the time of getting the engines to bear was twenty minutes, quickened to fifteen, and now perhaps now quickened more, but yet remains at double the time prescribed by Mr. Braidwood for efficiency. The subject was examined by a Select Committee, presided over by Sir Selwin Ibbetson, who rejected the system of the barracked force maintained by the Metropolitan Board of Works and their plan of water supply, and decided that the water supply should be placed as we had proposed, under unity on a public footing, and that fire protection should be charged upon the police, as at Manchester and Liverpool. This would have given to the suburbs and to the Metropolis the security of a night patrol of more than four thousand men, with the command of immediate appliances for the extinction of fires, which at a reduced expense would, during one decade, have prevented more than a thousand serious fires, and saved more than three hundred persons from being burned alive. I might describe the sanitary and economical advantages of placing the supplies of gas under unity on a public footing, as has been done at Manchester, Birmingham, and other places, leading to the reduction of the great smoke nuisance by extension of the use of gas in private houses, as well as in large manufactories, for which gas is now offered, also for the working of steam-engines at two-thirds the price of working them by coals. Sanitarians may, indeed, look forward to the abolition of the wide-spreading nuisance and waste of the big chimney.

The condition of legislation is continued at this excessive sacrifice of life and property. At this time there is a pressing demand for work for the unemployed. The provision of work, of useful work, as outdoor relief for the unemployed on occasions of large and sudden emergencies of destitution, was one of the principles of the Poor Law Amendment Act. That principle was early and variously applied, generally by road work. Road work was provided on occasions for Spitalfields weavers and cotton weavers in Lancashire. After some temporary soreness of the hands had been overcome, they many of them took to the work very well in return for the average of wages. But the largest provision of work was made by Sir Robert Rawlinson, and was made as no one else could have made it at the time, a provision of work, sanitary earth work for forty thousand unemployed men, of whom not much more than seven thousand men took advantage. What became of the rest? One social element is overlooked, that, as a rule, all have connections generally in other occupations. The cotton spinner may have had one who is an iron-worker, whom he visits and lives with, and who assisted him to find work elsewhere, or to emigrate rather than partake of the outdoor relief. By the social aid evoked in one form or another, the congestion for the greater part was reduced. For urban sanitation, two-thirds of the main drainage work is earthwork, which is available for rude labour under skilled superintendence. For undrained rural districts, and for suburban districts like this or Wandsworth Common, Wimbledon Common, Barnes Common, or Sheen Common, would well serve the purpose, and would repay the work by a contribution of superior soft and pure water, collected by subsoil drainage from unmanured surfaces, by the contribution to the reduction of the fog and unwholesome damps of the general site, and especially the suburban sites of the Metropolis. As a Sanitary Commissioner I bestowed great attention to the subject, and put together "minutes of information" for the practical working of subsoil land drainage. I was gratified to learn from the land agent of the late Duke Algernon of Northumberland, who expended at the rate of twenty thousand pounds per annum on the drainage of the land of his estates, that he had read all the treatises on land drainage, that these minutes of information he had found to be the most practical and valuable, and that for guidance in such work as his it would be well if those minutes were revised and brought down to the present time. There was one important result he noted—that an elevation of six degrees of temperature had been effected by the drainage of a thousand acres.

In England, land drainage, under the superintendence of the Commons Enclosure Commissioners, will pay itself in about seven years, or fourteen per cent., all round, and I have represented that it may pay itself similarly in Ireland, which is wetter than England, and may so pay itself, with double the average accustomed wages to the labourers engaged in the work.

For a part of the year good urban residences have the advantage of dryness of climate over the un-subsoil drained and damp suburban residences, especially those which are "over treed." Mr. William

Lindley, the engineer who rebuilt Hamburgh after the great fire, credited me with the principles of the system on which he supplied it with water and drained the new houses. There were people there who had left the old town for suburban residences, but who returned to the new town, finding it superior. Unless these suburbs are improved, this may take place with improved residences in the Metropolis, where the death-rate being the same, the climate at times is drier, and where the social advantages and the amusements are predominant.

Such, as I have stated, will be found to be the benefits that may be obtained by sanitation for the population by a drainage made under unity by a water service under unity, and by a road service under unity, for the whole of the Metropolis, including the suburbs. In my view, separate Commissions for these purposes would make the earliest, the safest, and the most economical preparation for a well-working Metropolitan Municipality. Some important sanitary work Putney and other suburban districts might do, under competent advice, such as the house drainage work and the sewerage. But it would be best to consider whether the co-operation of those of the other districts similarly interested in the riverside property should not be invited to save them from the certain extra expense and possible failure, like that which has occurred at Richmond and Mortlake, which has subjected them to an expense of a hundred thousand pounds for a plan which was rejected by a Select Committee as a failure; and from the wastefulness of that condemned vestral ignorance, which having estimated three millions for the purification of the Thames has expended six millions in the production of a condition, which Lord Bramwell's Commission have properly pronounced to be "a disgrace to the Metropolis and to civilisation." Four millions were enough to effect all the self-cleansing sewerage which the Metropolis requires with production of a sewerage which is fresh instead of putrid, and capable of the sustentation of some two hundred thousand cows now literally thrown into the sea. The miserable expedients proposed are in contravention of established sanitary principle—the retention of putrid sewage from ill-drained houses, its continued detention in a condition of putridity, in large sewers that are extended cesspools, and removed by frequent flushing. There is scarcely any flushing with properly constructed self-cleansing sewers. For them the flushing apparatus is only used in cases of accident. Having carried the putrid sewage to the outfall, they would need greater expense for its disinfection, or rather its deodorisation, than would be required for the direct application of the sewage that is fresh to agricultural production. All local administration of sanitary works may be tested by the nose in the house, in the street, or in the town or at the outfalls, or in the fields. True sanitation is a means of economy of the insurance charges of excessive sickness and premature mortality. The very certain doom of all who hear me is, of several years of excessive sickness and of the premature mortality of themselves and families during the existing insanitary conditions of the houses and the streets, and so in a greater or less degree of the other suburban districts. In labouring for a correct administration on tried and proved sanitary principles, we are labouring, therefore, for pecuniary economy as well as for the increase of health and strength, and for the extended duration of life.

Memoirs of Deceased Members.

The Council, having been requested to append some short notice of the decease of Members of this Association, will feel obliged by early notice being forwarded to the Secretary, with such particulars as it may be desirable to insert in these 'Proceedings.'

It is with much regret the Council have to record the death of Mr. James Hall, C.E., Borough Surveyor, Stockton-on-Tees, who died on June 14th, after a few hours' illness.

Mr. Hall was a native of Newcastle-on-Tyne, and served his articles under Mr. Spencer, C.E., of Newcastle and Tynemouth. Mr. Hall was appointed Surveyor to the South Stockton Local Board in 1874, which post he held until he was appointed Surveyor to the Stockton Corporation on the resignation of Mr. Edwards in 1878. During Mr. Hall's term of office, several works of considerable importance were carried out under his able superintendence.

Mr. Hall's kind and genial nature won for him the respect and esteem of all who knew him. He took a lively interest in this Association, and was one of the earliest to join it.

He was a Freemason, and occupied the chair in 1880; he died at the early age of 37 years.

The remaining death of which notification has been received is Mr. H. S. Aspinwall, late Borough Surveyor, Macclesfield, which took place in the latter part of 1885.

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